THE JULY SCIENTIFIC MONTHLY

Edited by

J. McKEEN CATTELL, F. R. MOULTON AND WARE CATTELL

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Compiled by a group of authors, the purpose of this book is to give a balanced, concrete view of resources and problems in their actual setting as a part of the organic units concerned, whether regions, states or the nation.

Fabre and Mathematics and Other Essays. L. G. SIMONS. 101 pp. $1.00. Scripta Mathematica.

A collection of essays which are to some extent biographical and historical. They are: Fabre and Mathematics; The Interest of Alexander von Humboldt in Mathematics; The Influence of French Mathematicians at the End of the Eighteenth Century; Short Stories in Colonial Geometry.

A History of World Civilization. J. E. SWAIN. Illustrated. xix + 615 pp. $4.00. McGraw-Hill.

The author intends that this volume should open up to the beginning student and the general reader the whole field of human knowledge. He has attempted to prevent a perspective of the entire cultural history of mankind.

The Logic of Modern Psychology. C. C. PRATT. xvi + 185 pp. $2.00. Macmillan.

A book on psychology dealing with words and concepts and not with material facts and empirical data. The author, who is professor of psychology at Rutgers University, terms his philosophy of psychology "Critical Positivism."

The Social Function of Science. J. D. BERNAL. Illustrated. xvi + 482 pp. $3.50. Macmillan.

The author, an English physicist, discusses the interrelationship between science and society. The volume is in two parts: "What Science Does" and "What Science Could Do." Much space is devoted to the organizations and methods of scientific men.

The Patient as a Person. G. C. ROBINSON. xiv + 423 pp. $3.00. The Commonwealth Fund.

A study of the social aspects of illness. The author believes the personality of the patient tends to be lost in the highly specialized and complicated organization of medical service as it exists to-day. The author was formerly dean of the Cornell University Medical School.

Problems in Prison Psychiatry. J. G. WILSON and M. J. PESCOR. 275 pp. $3.00. Caxton.

The author attempts to classify the prisoner on a purely psychological basis, describing in detail the effects of prison life upon character. He recounts the approved methods in vogue for mental and moral rehabilitation, setting forth the difficulties to be overcome, and evaluates the results so far obtained.

The Mechanism of Thought, Imagery, and Hallucination. J. ROSETT. Illustrated. x + 289 pp. $3.00. Columbia University Press.

A professor of neurology at Columbia University analyzes the mental process in this treatise for educators, psychiatrists and physicians. The author is also the scientific director of the Brain Research Foundation.

THE SCIENTIFIC MONTHLY

JULY, 1939

THE SCIENTIFIC WORK OF THE SECOND BYRD ANTARCTIC EXPEDITION

By Dr. THOS. C. POULTER

SECOND IN COMMAND OF EXPEDITION; DIRECTOR OF RESEARCH FOUNDATION, ARMOUR INSTITUTE OF TECHNOLOGY

THE second Byrd Antarctic Expedition embarked from Boston on October 11, 1933. After passing through the Panama Canal, we touched Easter Island, then crossed the Pacific to Wellington, New Zealand. A southeast course from there brought our vessel into ice-filled Antarctic waters east of the Ross Sea. A large area of unknown ocean was explored by ship and airplane as far east as the 116th meridian, where we turned westward again. One month after the ship had first entered the pack-ice, it reached the southernmost shore of the Ross Sea. The Bay of Whales is that point on the circumference of the Antarctic continent where the ocean encroaches farthest toward the pole. Here at 78° 34′ S. and 163° 56′ W., the base camp was established on the floating shelf ice of the Ross Barrier. The ice-party occupied the Bay of Whales base from January 17, 1934, until February 5, 1935, while the ships wintered in New Zealand. The itinerary of the return voyage included Dunedin, New Zealand, Easter Island, Albemarle Island, of the Galapagos archipelago, and Panama. The expedition arrived in the United States on May 10, 1935, after an absence of nineteen months.

More than two years had been spent in making very elaborate preparations for a comprehensive scientific program. It is gratifying to find in summarizing the accomplishments of the expedition that a great deal of the original program has been carried out. This paper briefly summarizes the scientific accomplishments of the expedition. The complete report will occupy the equivalent of about ten volumes of three hundred pages each.

OCEANOGRAPHY

The oceanographic program of the expedition included a systematic bathymetric survey in the form of echo soundings taken hourly, *i.e.*, about seven miles apart except when an outstanding change in bottom configuration was encountered or when the continental insular shelf was approached and left. On these occasions the number of soundings was increased to whatever number was required to obtain a detailed profile of the bottom. In all, ten series totalling 2,723 soundings were made from the *Bear of Oakland* during its two trips to and from the Antarctic and on cruises while there.

COSMIC RAYS

In order to extend the cosmic-ray measurements of the world-wide survey made by Dr. A. H. Compton, of the University of Chicago, into the south Pacific and the Antarctic, a large number of cosmic-ray measurements were made on our southern voyage and during our stay at Little America.

ICE STUDIES

A very extensive study was made of the ice conditions from the time we sighted

AERIAL VIEW OF THE ICE PACK, APPROACHING THE ANTARCTIC
THE LARGER PIECES ARE ABOUT A MILE IN DIAMETER AND A HUNDRED FEET THICK.

our first ice and continued throughout our stay in the Antarctic.

Aerial photographs of the pack-ice and icebergs supplement the pictures and records made from the two ships. The largest individual bergs covered an area of two hundred square miles. Studies were made of the stratification, porosity, general structure and movement of the continental and shelf ice.

That vast extent of about 100,000 square miles of shelf ice between the Ross Sea and the Queen Maud Mountains was found to average more than a thousand feet in thickness, and that portion of it forming the west edge of the Bay of Whales was found to be moving northward and a little to the east at an average rate of eight feet per day, and the ice on which Little America was built was moving westward at the rate of two feet per day.

The frequent boom of snow tremors, allowing the snow underfoot to drop suddenly sometimes more than an inch, kept the surface traveler constantly reminded of that great dread of the Antarctic, the so-called blind crevasses.

Ornithology

Fifty-four species of birds were identified in the course of the second expedition. Twenty-three of these were non-oceanic birds which came aboard ship from October 14 to 30 between New York and Panama. Nine species of sparrows and four species of warblers were among the passerine birds.

The ornithological collection of the expedition consists of one hundred and seventeen skins, chiefly of the larger oceanic birds. Twenty species are included, representing ten families.

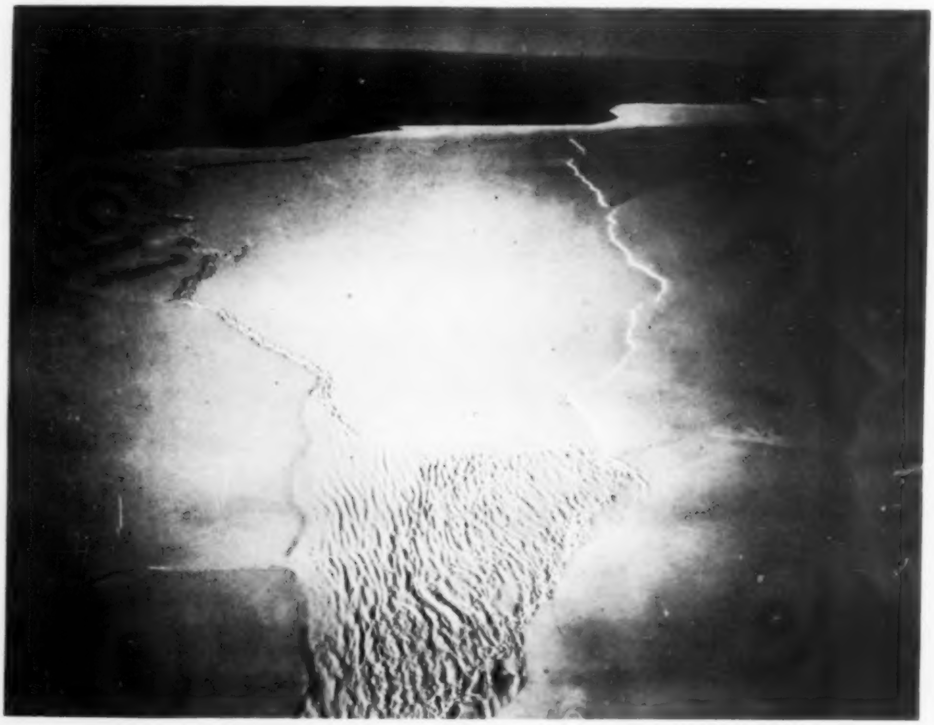
The Antarctic pack is a purgatory for the navigator, but a paradise for the observer of bird and mammal life. Unfortunately for the latter, no pack-ice was encountered on our return voyage. How-

ever, this brought a measure of compensation in its effect on the southward occurrence of albatrosses, so that the known non-breeding ranges of three species were extended. The most southerly range of light-mantled sooty albatross, the black-browed albatross, the stately wandering albatross was extended 230, 210 and 100 geographical miles, respectively, for the three species. In the "roaring forties" two male wandering albatrosses were collected, the larger weighing nineteen pounds and measuring ten feet and nine inches in extent.

The snow petrel is the most abundant bird in the pack-ice. It lives largely on the shrimp-like reddish crustacean which is also the principal food of the Adelie penguin, the crab-eater seal and other denizens of the Antarctic pack. The snow petrel's plumage is white, with ivory tones; its beak, eyes, tarsi and feet are black. This would be an altogether attractive bird were it not for its accuracy and eight-foot range in ejecting the oily, orange-colored contents of its stomach at the intruder.

The sun reappears at the Bay of Whales on August 22. The earliest spring migrants are the snow and Antarctic petrels. A lone snow petrel and two Antarctic petrels arrived on October 6, but they did not become common on the bay until December, or midsummer. The last snow petrel seen in the autumn was on March 13, after which no birds of any kind were observed.

No birds breed in the Bay of Whales



AIRPLANE VIEW OF THE BAY OF WHALES

IN EARLY SUMMER BEFORE THE ICE HAD GONE OUT—TAKEN FROM ELEVATION OF ABOUT 15,000 FEET. THE PORTION CLEARED OF ICE THE PRECEDING SUMMER IS SHOWN IN THE UPPER CENTER; THE PORTION NOT CLEARED, IN THE LOWER CENTER. LITTLE AMERICA IS TO THE RIGHT OF WHERE THE NEW ICE JOINS THE OLD.

GENERAL VIEW OF LITTLE AMERICA BEFORE IT HAD BEEN COMPLETELY DRIFTED OVER WITH SNOW.

region. The only known breeding ground within four hundred miles is a rookery of snow petrels discovered by a four-man sledging party which Siple led into the mountain ranges of Marie Byrd Land.

On the lower slopes of Mount Helen Washington on December 19, 1934, the rookery was located, where snow petrels were sitting on their eggs deep in the crevices among the rocks. They defended their nests with the customary marksmanship. No nests of the Antarctic petrel were found, but from the numbers of the birds it seems likely that they nest on this peak with the snow petrels. A fact of unusual interest is the distance of this nesting site from the nearest water. The birds nest fifty-one statute miles from their nearest possible source of food. This disadvantage seems to be counterbalanced by the nature of the peak, where many sheltered nesting sites are available among the loosely aggregated rocks. Winds of hurricane force sweep over the peak to prevent large accumulations of snow, while the dark rock contributes by absorbing the sun's heat and melting the snow. Finding this rookery extends the breeding range of the snow petrel 452 statute miles to the south.

In the ice-pack in January, flocks of hundreds of Antarctic petrels were seen wheeling in unison above the great tabular bergs. About seventeen inches in length, or three inches longer than the snow petrel, this bird is no less beautiful. Its chocolate-brown head, back and wings furnish a pleasing contrast with the whiteness of the wing coverts and other parts.

The silver-gray petrel is the least common of the birds known to visit the Bay of Whales. Our only specimen collected was secured on the Antarctic Circle and the 150th meridian, at the northern edge of the pack.

The Cape pigeon has never been reported in the Bay of Whales. The Wilson's storm petrel breeds only on Antarctic and sub-Antarctic islands and on

EMPEROR PENGUINS

shores of the Antarctic continent. This species migrates as far north as Labrador during the southern winter. As for all birds which reach the Bay of Whales, except the South Polar skua, this station marks its southernmost limit. We never saw them alight on the ice.

The giant fulmar, or giant petrel, appeared at Discovery Inlet, but not one had been reported at the Bay of Whales until the autumn of 1933. This species has two color phases, a brown and a white, with intermediate conditions. In cruising along the barrier cliff between

PRESSURE ICE IN THE VICINITY OF LITTLE AMERICA.

the Bay of Whales and Discovery Inlet, we saw a flock of about fifty which had settled on an ice floe. Within the scope of our observations the white birds constituted only 3.3 per cent. of the sixty individuals, as compared with Wilson's 23 per cent.

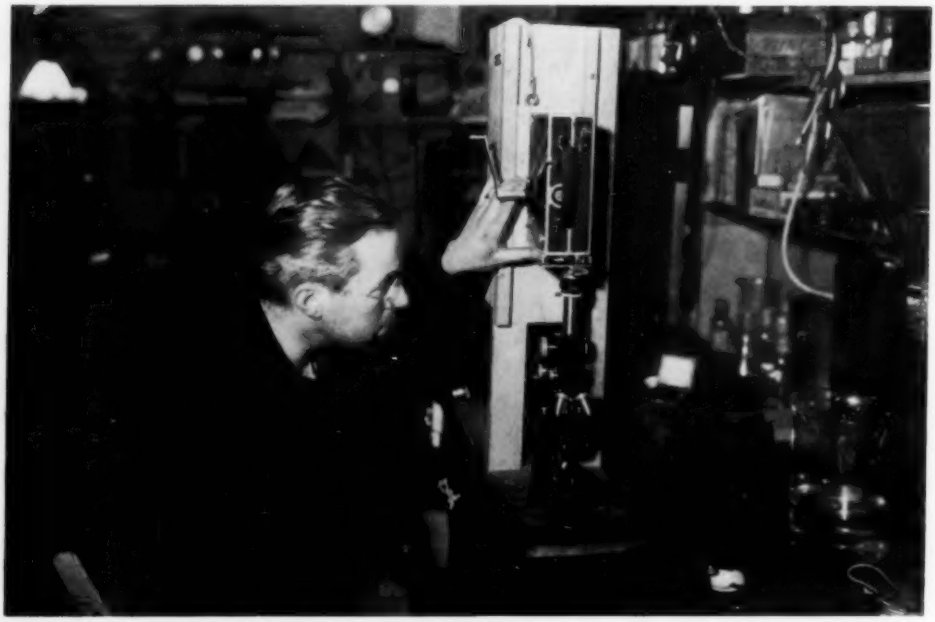
The drama of Antarctic bird life is not without its villain. Theft and pillage, murder, cannibalism and infanticide, these crimes are all in the repertory of the South Polar skua. The Adelie penguins are immune to this plague only because they nest in the middle of winter, sharing with no other bird species the rigor of the polar night. At the aforementioned snow petrel rookery there were skuas about. Doubtless the petrels' habit of laying their eggs in narrow crannies serves to protect the eggs and young from skuas, as well as from the force of frequent blizzards. The South Polar skua wanders farther south over the continent than any other bird. The southern geological party reported an observation made by this party at 86° 05′ S., thirty miles up the Thorne Glacier, at an altitude over two thousand feet. The birds settled on the snow near the dog lines, rested for a time and finally took off, flying north, continuing the flight down the glacier. These facts suggest that the skuas may have been on a flight across the Antarctic continent.

The emperor penguins, the largest of living penguins, were more frequent visitors to the Bay of Whales than the Adelies in 1934–35, but the reverse was true in 1929–30. Their remarkable habit of breeding during the extreme cold and darkness of the Antarctic night leaves them free in summer to wander along the coast and through the ice-pack. Many emperors are to be seen in the pack during December and January, both juvenile and black-throated birds. Others of both groups seek coastal bay ice, such as the Bay of Whales affords, on which to moult. Although conspicuous by virtue of their size, coloration and loud reedy, whining call-note, emperors are by no means abundant in the bay. Through-

THE BIOLOGICAL STAFF AT WORK IN THE SCIENCE LABORATORY.
EXAMINING BACTERIA, PLANKTON, MOSSES AND ALGAE COLLECTED IN ANTARCTICA.

SCIENTIFIC STAFF MEETING IN THE SCIENCE LABORATORY.
DR. POULTER IS AT THE HEAD OF THE TABLE.

out the summer of 1934–35, though we were on the bay almost daily for three months, the total number of emperors seen was only thirty-two. The first in the spring appeared on November 5, after which none was seen for a month. Eighteen specimens taken in November and December, before the moult, ranged from 60 to 84 pounds, while eleven taken after the moult in February ranged from 39 to



DR. PERKINS MAKING MOVING PICTURE RECORDS OF LIVING PLANKTON SPECIMENS.

55 pounds. Motion picture and sound records were made of the emperor and Adelie penguins.

After an unsuccessful attempt on the first Byrd expedition to bring back living Antarctic penguins for American zoos, another attempt was made on the second trip. The captives were kept at the base camp, where an area of about 5,000 square feet of snow was enclosed by a wire netting. The first birds caught were kept there for two months before being transferred to the ship. Frozen fish had been purchased in New Zealand for feeding them.

On leaving the Antarctic we had twenty-one captive Adelies and nineteen emperors housed amidships in an air-conditioned, refrigerated, cork-insulated room forty feet long, six feet wide and seven feet high. After three weeks at sea, when the birds had been kept for two or three months in captivity, most of the emperors no longer required forcible feeding. On the contrary, they had become very tame and friendly, since a new association had finally been formed and man now symbolized food. The young emperors were far behind the adults in their conditioning to hand-feeding, and were more vicious in defending themselves against being fed. The Adelies showed still less adaptability and more pugnacity. Their stout hooked beaks proved much more formidable weapons than the long, curved bills of the emperors. If the powerful emperors had fought as strenuously in proportion to size, keeping them alive would have been quite impossible.

Unfortunately for the captives, the return voyage to America took more than three months, due to the slow pace of the ships and an extended stay in New Zealand, where many of the Adelies died. By the time the expedition had crossed the tropics, nine of the emperors had died from a heavy mycosis infection of the

lungs, tracheae and air sacs. Ten emperors and one Adelie penguin reached the United States alive and were delivered to the Chicago Zoological Society. The last of these died about two months later of the same disease. The society transferred these birds to the Field Museum of Natural History, where they are now on display as a habitat group.

Plankton and Invertebrates

Plankton samples were collected on the various voyages of the two expedition ships, and dredge hauls were made in the Bay of Whales. Photomicrographic and cinemicrographic records were made of all materials collected.

The bottom fauna included sponges, coelenterates, bryozoans, brachiopods, polychaete and sipunculid worms, pycnogonids, bivalve molluscs, all classes of echinoderms and tunicates.

Bacteriology

Aseptically collected samples were collected from the environs of Little America, from many points on the snow surface within 400 miles of Little America, from morainic alluvium, lichens, mosses, exposures of mud and water known to contain algae, rotifers and infusoria, mud from 3,000-feet depth in the Bay of Whales, infections caused from handling seal blubber, abandoned rooms of the B.A.E. I, agar plates, which were exposed on mountain peaks never previously visited by man, and from snow on Thorne Glacier within 180 miles of the South Pole.

At Little America, Siple and Sterrett

MR. GRIMMINGER MAKING PILOT BALLOON OBSERVATIONS AT 70° BELOW ZERO.

TWO OF FOUR METEOR OBSERVERS SEATED ON A ROTATING PLATFORM.
THE MAN SEATED BELOW IS RECORDING THE OBSERVATIONS. THE RETICLES THROUGH WHICH THEY LOOK AT THE SKY ARE SHOWN IN THE NEXT PICTURE.

had sufficient equipment to make isolations from snow samples; however, cramped quarters and dangers from mold contamination made it advisable to abandon most of the research to laboratories outside the Antarctic. Some thirteen isolations were taken from the snow and other sources. As to distribution it was found that probably as few as one or two bacteria exist on the average pint of Antarctic surface snow. The majority of aseptically taken samples were brought back sealed and opened for the first time in the bacteriology laboratory of Allegheny College, Meadville, Pennsylvania.

There are perhaps, at least, 75 different kinds of bacteria. In addition to the two yeasts, there are twelve coccus forms, while the remainder are rods and perhaps half of the collection are spore-forming bacilli.

Botany

The Marie Byrd Land exploring party, composed of Paul A. Siple as biologist, Alton Wade as geologist and S. Corey and O. Stancliff as assistants and dog drivers, returned to Little America after a three-months intensive sledding journey in December, 1934, with an unusually large collection of mosses, lichens and algae native to the Nunataks of that land. This collection was supplemented by the collection made by the Queen Maud Geological Party. The collection was packed in a strong box and not disturbed to any extent until turned over to Dr. Carrol W. Dodge and Mr. Edwin Bartram.

From the thousands of plant colonies reviewed in the field and hundreds brought back to the laboratory for identification, at least 89 species of lichens and five mosses have been determined. The

lichens were collected from some 215 distinct locations and 12 mountains, and on 8 of the 12 mountains there were relatively few mosses. This collection no doubt represents the majority of the larger and more conspicuous species, but most of the mountains had species apparently restricted to them. Of the mountain exposures where plant life probably exists, less than 10 per cent. of the area has been visited.

In the light of observations made in Marie Byrd Land, it seems probable that the plant species of Antarctica are much more numerous on the continent proper than the one or two hundred known species thus far collected would indicate.

Museum Specimens

A collection of museum skins was obtained for the American Museum of Natural History, including 43 Weddel and crab-eater seal skins with accompanying skulls. Additional skulls of both species, making a total of 112 skulls, a large number of embryo seals, chiefly those of the Weddel seal, were also collected.

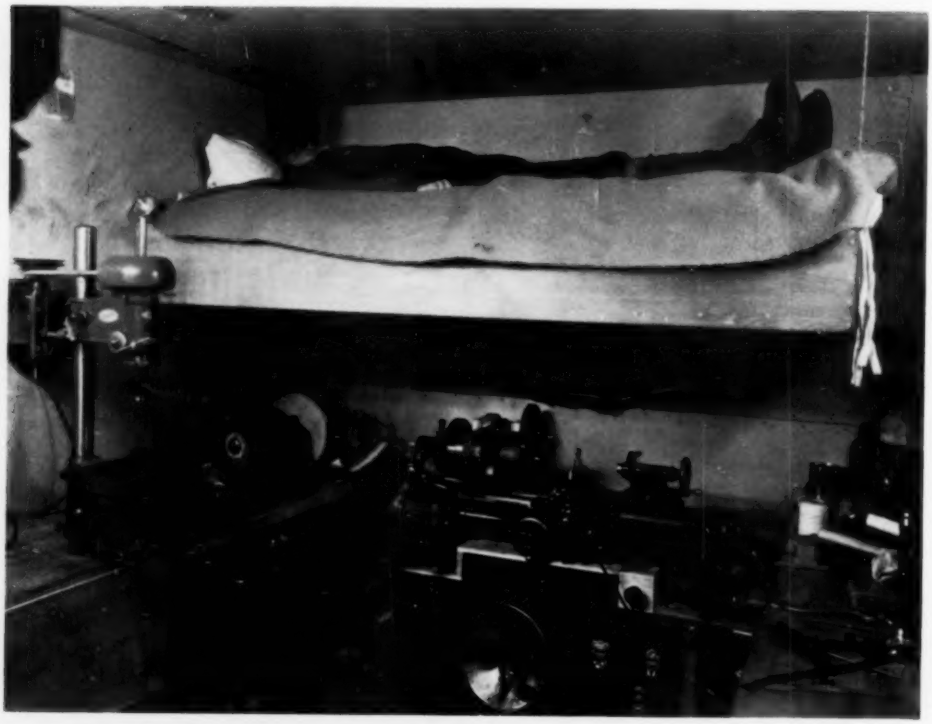
One hundred and twelve oceanic bird skins of about twenty species, including penguins, albatrosses, skua gulls, shearwaters, petrels, frigate-birds, boobies, tropic birds, etc., are included in the collection.

Fish of the genus Pleurogramma and a new Antarctic fish "Pagothenia," in addition to two flying fish, reef fish from Easter Island and sea basses and mackerel from the Galapagos Islands constituted a part of the collections.

Medical

A study was made of the physical effects of the Antarctic conditions upon the personnel of the expedition. Each member was subjected to a physical examination, including a blood count, tak-

RETICLES USED IN DETERMINING PATHS OF METEORS.
MOUNTED ON TOP OF A SHACK, WHICH IS BURIED UNDER THE SNOW.



OBSERVING METEORS WITH BINOCULARS FROM THE WORKSHOP AND OBSERVATORY.

ing of blood pressure and a general physical condition check-up once each month during the winter night. The treatment and effect of frost bite, snow blindness and other conditions peculiar to the Antarctic were studied.

In addition there was an appendectomy performed, a case of streptococcus throat infection, plus other numerous infections and sprains.

Meteorology

The meteorology observations constituted one of the major activities of the expedition. In addition to the two meteorologists making continuous observations of weather conditions at Little America throughout our stay there, pilot balloon observations were made twice daily, and on certain occasions every few hours.

Aerological soundings were made with the autogyro, Pilgrim and Condor planes at frequent intervals from September, 1934, to February, 1935. The three major field parties kept complete records of conditions encountered during the nearly three months they were on the trail.

For the first time in the history of Antarctic exploration, an inland weather station was established, the Bolling Advance Base, occupied for seven months by Admiral Byrd, including the long winter night. The set of weather observations made by Admiral Byrd in spite of the almost impossible conditions under which he was forced to work are surprisingly complete and constitute one of the most valuable chapters in Antarctic weather records.

Temperatures ranged from only a few degrees above freezing to more than 80

degrees below zero, and one period of six weeks averaged more than 60 degrees below zero.

The average wind velocity at Little America of eleven miles per hour is considerably lower than at many places in the Antarctic. The maximum velocity on the continent was 60 miles per hour, while higher velocities were encountered at sea.

ASTRONOMY

The Aurora Australis is visible at Little America more than half of the time that conditions are favorable for seeing it, and about two hundred and fifty photographs were taken of typical aurora forms and a great many visual records were made.

Because of the interference of bad weather, sunlight, moonlight and auroral light, it was only possible to make meteor records over an observing time totalling a little less than seven days. However, in this time observations were made on about seven thousand meteors.

Two distinct methods of observing were employed, and in both of them most of the observations were made with the observer in a heated shack. One method was with the unaided eye and the use of a reticle which served as an arbitrary system of coordinates. For these observations from one to four observers were seated on a rotating platform in such a way that the observer's eye came directly behind an opening in the small dome of the roof of the shack. The four reticles were mounted in the roof of the shack so that the center of the field covered by each of the four observers was at an elevation

TELEPHONING FROM THE SCIENCE LABORATORY

DR. BRAMHALL, PHYSICIST, COMMUNICATING WITH AN ASSISTANT IN THE MAGNETIC OBSERVATORY.

of about 45 degrees, and the four reticles pointed in each of the four directions. The platform was rotated a quarter of a revolution once every fifteen minutes so that in a regular two-hour period each of the observers had observed twice in each of the four positions. Nearly two thousand meteors were observed by this method, and the coordinates of both ends of the path recorded, together with the time to the nearest second, magnitude, color and duration of train, if one.

One observer observing through an eyepiece and reticle mounted in the roof of the shack permitted observations to be made in the Zenith. About one thousand meteors were observed through this reticle, and the complete data recorded for each meteor.

The other method involved the use of 7 × 50 Zeiss U. S. Navy Binoculars. They were mounted in the ceiling of the shack and directed at the Zenith. They covered a field of about seven degrees, and about 1,300 meteors were observed by this method. The same data were recorded for these as in the case where the reticle was used. The number that it was possible to record by this method depended upon the speed with which the observer could call off the positions and the recorder could take them down, as they were appearing much faster than it was possible to record data.

Because of the rate at which meteors could be observed with binoculars when the visibility was very good, it was decided to record only one number for each meteor and that representing the direction that it was traveling. In this way observations were made on about 1,500 meteors, and the rate at which they were recorded varied from 6 to 35 per minute.

A reticle was taken to Advance Base during the latter part of the winter night, and a series of simultaneous observations were made with two observers watching the same section of the sky for the determination of real heights. This gave a base line of about 100 miles. While the

BROADCASTING CONTROL ROOM AT LITTLE AMERICA.

GEOPHYSICS PARTY ON THE TRAIL.
MAKING A SURVEY OF THE BAY OF WHALES REGION. NOTE THE SEALS ASLEEP ON THE ICE IN THE BACKGROUND.

number of actual duplicates observed was rather small, several hundred meteors were recorded during these observations.

Data were recorded on all fireballs observed by any of the members of the expedition. Five meteors left trains lasting long enough for the drift to be measured, thereby making it possible to determine the direction and approximate velocity of the wind at an elevation of between 50 and 100 miles above the surface of the earth. In all five cases, the drift was from west to east at a rate of about 150 miles per hour.

Insofar as was possible the observations were distributed through the twenty-four hours so as to obtain, if possible, the diurnal variation in the numbers of meteors striking the earth's surface.

Observations were also made on the magnitude of the two variable stars, Beta Doradus and Carinae, at frequent intervals throughout the winter night. A large number of star sights were also made through the winter night for accurately determining the position of Little America and Advance Base. Many of these were made at a temperature of more than 70 degrees below zero.

Terrestrial Magnetism

With the aid of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, the expedition was completely equipped with continuous recording magnetic instruments as well as instruments for making absolute measurements of Little America and on the trail. In addition to the many field observations in the Antarctic, measurements were made at Easter Island, Albemarle Island, Panama Canal Zone and New Zealand.

Geophysics

The mystery of what lay hidden beneath the snow surface in the Antarctic led us to include in our scientific equipment an instrument new in polar exploration and research. This was a geophysics seismograph with which we were able to measure the thickness of the ice, tell whether it was resting on rock or floating on water, and if floating on water

how thick the water layer was and something about the stratification of the bottom. With this equipment we made more than 500 soundings at 135 stations.

These measurements explained many of the mysteries of the Ross Shelf Ice, such as crevassed areas, the existence of the Bay of Whales, Discovery Inlet, Lindbergh Inlet, as well as proved the existence of Roosevelt Land.

We traveled 2,000 miles on skis with this equipment and an equal distance by plane, measuring continental ice thicknesses of more than 2,000 feet and floating ice of 1,500 feet.

Geology

The geological program of the expedition was one in which there was a great deal of activity. Fourteen mountains in the Edsel Ford range were visited by the Marie Byrd Land party. The range was found to be composed of greatly folded and higher metamorphosed sediments which have been uplifted and intruded by massive and granodiorites. The structure of these mountains was observed and the effects of the Antarctic agents of weathering on the rocks was studied. An extinct volcanic cone composed of an olivene basalt was discovered and visited. The party stopped at Mount Helen Washington in the Rockefeller Mountains on the homeward journey to collect specimens for correlation of this range with the Edsel Ford Range.

Rocks and pebbles collected from an iceberg at sea, and those taken from the stomachs of seals and penguins, together with those obtained in dredgings from the bottom of the Bay of Whales have been studied to see where they fit into the geologic picture of the Antarctic.

Another major geologic endeavor of the expedition was that of the Queen Maud Range party. Blackburn, leader of the party, was assisted by Paine and Russell in the trip across the Ross Shelf Ice to the Queen Maud Mountains and ascent of the Thorne Glacier. They painstakingly collected specimens and recorded data for the construction of a cross-section of this range, paying particular attention to the sedimentary beds near the top on which many fossils, leaves, branches and even tree trunks were found. Twenty different seams of coal were found exposed along the side of the glacier.

Radio

During the weekly broadcasts and daily communications with the United States and Expedition ships, the radio engineers made frequent records of transmission and reception conditions, the interference accompanying displays, magnetic disturbances and audio static.

Space here does not permit adequate acknowledgment of our sincere appreciation of the valuable assistance and cooperation that we have received from the large number of scientists and scientific organizations.

FOREST PYROLOGY

By H. T. GISBORNE

SENIOR SILVICULTURIST, NORTHERN ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

AMERICAN forestry inherited from European practices no science or technology of fire control. No formalistic theories nor established foundations of knowledge were available for fire such as were inherited for silviculture, wood technology, forest pathology and forest entomology. There was no science of forest pyrology.

It was not until 1916, in fact, that a specific proposal was formally made to apply research methods to fire as a forest phenomenon, and not until 1926 that the research possibilities were stated in detail. In both cases, Dr. Earle H. Clapp, associate chief, U. S. Forest Service, was the author, and his second proposal, contained in "A National Program of Forest Research," published in 1926 by the American Tree Association, has been and still is the master working plan for the guidance of forest fire research in evolving a science of forest pyrology.

This national program distinguished six components of the fire problem: (1) The laws governing the combustion of forest fuels in the open; (2) fire prevention techniques; (3) fire suppression, including the generalship and tactics, the tools and instruments of this craft; (4) the accurate determination of all forms of damage due to fire; (5) the beneficial uses of fire; (6) the protection standards or objectives which fire control should attempt to attain.

(1) LAWS OF COMBUSTION

Classification has been called "the very essence of scientific method" and a classification of the fuels that burn in forest fires was one feature of the laws of combustion specifically identified by the national program. The need for classifying the many diverse types of fuels which are the *sine qua non* of forest fires is obvious when one remembers that on an average bad fire day the combustion process progresses at only a few square feet per hour in some fuel types, whereas in others the area burned has been as great as 1,000 *acres* or more per hour. As W. I. Wyman has stated:

> To bring like things together to form distinct groups and to separate groups according to their distinguishing properties are measures that consciously or unconsciously have been adopted by humanity from time immemorial. This cerebral process is a method of classification and is not only the basis of any scientific system but is an active principle in all systematic procedure. All ordered thought is based upon it, all ordered performances require it. Dictionaries, directories, correspondence files and trade catalogues are instances of modern requirements in domestic and business life.

In the business of forest fire control research has applied this principle to replace the personal memory and estimate bases formerly employed to determine how many fire control men are needed and where they should be located. The "ordered performance" of fire control obviously will progress faster by systematic rather than subconscious identification and grouping of these basic factors of fuel type.

Show and Kotok pioneered in this attack on fuel type classification evolving a silvical basis for the California forests. Hornby, of the Northern Rocky Mountain Forest and Range Experiment Station, refined this by originating a pyrological basis with definitions of those generic characteristics indicative of (a) rate of spread of fire and (b) resistance to control. Tested by application on

A FOREST FIRE DANGER RESEARCH STATION IN THE "HIGH COUNTRY"

ELEVATION 5,500 FEET, ON THE PRIEST RIVER EXPERIMENTAL FOREST. TEMPERATURE, HUMIDITY, WIND VELOCITY, DUFF MOISTURE AND SMALL STICK MOISTURE ARE RECORDED AUTOMATICALLY. PRECIPITATION IS MEASURED BY GAGES.

17,000,000 acres of national forest, this classification has demonstrated both its scientific soundness and its practical value. More recently, Matthews, of the Pacific Northwest Station, and Curry and Fons, of the California Station, have further advanced the methods of enumeration and quantitative estimate of the elements, in California to the stage of formulation for one fuel type of a rate of spread hypothesis in mathematical form, soon to be published.

The National Program definitely recognized the function of fuel moisture as a major control in the combustion process. The problem here was decidedly similar to that existing and later described by Livingston for physiological plant ecology when he stated in 1935 that much must still be done "before we shall be able to devise instruments and techniques by means of which numerical indices of environmental capacity may be secured." "Just what to measure must depend, to a considerable extent and for a long time to come, on what we are able to measure."

Instrumentation, so important to the physiological ecologist, constituted a major impediment to the early progress of forest pyrology. The low-cost rain gage, designed by Osborne and improved by McArdle, the low-cost wind gages of the Northern Rocky Mountain and the Pacific Northwest Stations, the fan psychrometer, duff hygrometer, wood cylinders, visibility meters and the anemohygrograph not yet described in any publication have, however, partially or wholly removed some of these impediments. Savings of some $6,500 in the cost of rain gages, and $17,000 in the cost of anemometers, with resultant possibilities of more wide-spread measurement, have already been made as a result of this instrumental research, while the invention of duff hygrometers and wood cylinders made possible the measurement of highly significant danger factors which formerly had to be crudely estimated.

Research at several experiment stations soon found that except for wind the meteorological elements of insolation, temperature, humidity and precipitation are largely factors of environmental capacity which influence fire behavior only as they affect fuel moisture. They are, therefore, indirect indices at best. The correlations by Mitchell for the Lake States, Stickel for the Adirondacks and Jemison for the northern Rocky Mountain region have been valuable, however, both in classifying fire danger on the basis of meteorological records alone, in the absence of fuel moisture data, and for evaluating the controls of fuel moisture, or the cause and effect relationships.

The scientifically essential equilibrium relations between temperature, humidity and fuel moisture were first derived by Dunlap, of the U. S. Forest Products Laboratory, for coniferous fuels in 1924 and for hardwood forest leaves in 1931. Hawley, of the same laboratory, contributed basic information concerning the laws of combustion by his summarization of certain physico-chemical relations applicable to free-burning forest fuels.

The effect of fuel moisture on the ease of ignition and inflammability of the duff and litter comprising the forest floor under coniferous stands was early determined in terms of common sources of ignition by Gisborne and Stickel. The inflammability of dead branchwood, of green, curing and cured shrubs, grasses and weeds, and of combinations of fuels, the effect of slope and size of fire on rate of spread and many other factors of combustion, however, still remain to be determined. As yet, only at the California and Northern Rocky Mountain Stations have certain phases of these problems been brought into the laboratory for controlled examination by physicists and chemists.

(2) Fire Prevention

The classification of fuels on a pyro-

THE PRIEST RIVER FIELD LABORATORY
OF THE NORTHERN ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION, LOCATED ON THE KANIKSU NATIONAL FOREST IN NORTHERN IDAHO.

logical basis, by Hornby, and the determination of effect of forest canopy density on the inflammability of some of these fuels, by Jemison, have already given the forest executive sound principles of immunization for his guidance in the reduction of inflammable material along rights-of-way, around campgrounds and on all areas exceptionally exposed to the causative agencies. A much more efficient railroad engine spark arrester of the cyclone type, invented by a railroad master mechanic but not well accepted until proven by research-conducted tests at the Northern Rocky Mountain Station, has materially affected the prevention of railroad fires, with great benefits both to the railroads and to all forest protective agencies in the northern Rocky Mountain region. On one national forest alone, use of this arrester by the transcontinental railroad crossing this forest has reduced the number of railroad fires from an average of one fire per two trains in 1931 to about one fire per eight trains in 1936 and 1937.

Immunization by closure of forest areas, by smoking and camping regulations and public warnings has for several years in the northern Rocky Mountain region of the Forest Service been practiced by using the fire danger measurements evolved by the Northern Rocky Mountain Forest and Range Experiment Station as the basis for this form of prevention. The prediction of dangerous fire weather, recognized by the National Program as one aid to fire prevention, has been untouched by the forest experiment stations on the premise that such forecasts are preeminently the field of the U. S. Weather Bureau.

Lightning, the single unpreventable cause of forest fires, has been studied by

the Weather Bureau and the Forest Experiment Stations in regions of high lightning danger, with resultant increased accuracy of forecasts as well as identification of dangerous versus safe characteristics of storms.

Forest fire insurance, an economic phase dependent upon local conditions of combustibility and the activity of the causative agencies, has been thoroughly investigated by Shepard, of the Pacific Northwest Experiment Station, with the finding that insurance rates need not be prohibitive in that region.

(3) Fire Suppression

The research attack here has been largely on two phases—danger measurement and fire control planning, analogous to diagnosis and disease treatment in medicine. The major factors of fire danger were first identified and integrated into a numerical scale by the Northern Rocky Mountain Experiment Station, which adopted, for the integration, a device called a danger meter. Similar meters suited to local conditions have since been produced by the Lake States and Appalachian Stations, and a danger board employing tabular integration has been designed by the Pacific Northwest Station. The California and New England Stations are expected soon to utilize similar principles to aid diagnosis of the current status of danger for their regions. In all cases, the end-product is a numerical rating of fire danger, each class of danger signifying a specific size of fire control organization needed to furnish adequate protection.

The scientific procedure here has been

A CORNER OF THE CHEMISTRY LABORATORY AT THE PRIEST RIVER STATION
CHEMICAL ANALYSES AND CALORIE PER GRAM DETERMINATIONS ARE MADE AT 10-DAY INTERVALS, MAY TO SEPTEMBER, FOR NINE SPECIES OF GRASSES, HERBS AND SHRUBS TO DETERMINE THE EFFECTS OF GREEN VEGETATION ON FOREST FIRE DANGER.

THE PRINCIPAL METEOROLOGICAL STATION AT THE PRIEST RIVER BRANCH OF THE NORTHERN ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION. TEMPERATURE, HUMIDITY, WIND VELOCITY, WIND DIRECTION, PRECIPITATION AND DURATION OF SUNSHINE ARE MEASURED AND RECORDED AUTOMATICALLY BY INSTRUMENTS IN THE FOREGROUND AND AT THE TOP OF THE 150-FOOT TOWER IN THE BACKGROUND.

similar to that employed by Birkhoff[1] in originating esthetic measures. Positive and negative elements, formerly left to personal selection and evaluation, and therefore dependent upon "the idiosyncrasies of the individual mind," have now been identified, measured, integrated and reduced to formalistic theory susceptible of verification or disproof. Administrative forest officers have contributed in many ways to this research, the intimate association of Forest Service administration and research aiding especially the field trials for verification or disproof. Such trials are now in their fifth season, in the northern Rocky Mountain region, and in no case, as yet, have the ratings failed to identify the higher dangers which have in the past cost so much in area burned over and resources destroyed.

The second phase of fire suppression research, or fire control planning, was first studied by many administrative men, notably DuBois[2] in California. Silcox stressed the need for research analysis of this phase as early as 1916 when he stated, "To approach anything like a satisfactory solution of the fire-protective problem, demands a clear thinking out of a plan or organization subdivided into its constituent, elementary parts." He identified these subdivisions as prevention, detection, control and finances, recognizing in the latter a

[1] G. D. Birkhoff, SCIENTIFIC MONTHLY, April, 1938, pp. 351–357.

[2] Coert DuBois, "Systematic Fire Protection in California Forests." U. S. Department of Agriculture. (Not for public distribution.) 1914.

factor of basic importance which has since been frequently overlooked, and which has all too often been the major control of the prevention, detection and suppression action actually taken. Show and Kotok followed Silcox with a research analysis of the California fire records evolving certain principles which determine "hour control" or the speed with which fires must be attacked. Norcross and Norcross and Grefe contributed materially by their methodical treatment of the transportation elements basic to speed of attack. Hornby, of the Northern Rocky Mountain Station, then developed his principles of procedure, which embraced all the old and many new factors and which by its methodology brought such work clearly into the classification of forest pyrology.

Hornby's principles of fire control planning have revolutionized in many respects and have universally revitalized the former "rules of thumb" and individualistic procedures of determining how many detection men, fire chasers, suppression crews, etc., should be provided for any particular forest property. Based upon the three definite fundamentals—values at stake, occurrence rate and fuel types—Hornby's procedures constitute a system reducing idiosyncrasies of individual opinion to a near minimum. They determine not only how many men are needed for each class of measured danger, but also where these men should be located; consequently, where all lookout buildings, guard stations and many ranger stations should be built. These in turn determine the termini of all roads, trails and telephone lines both to service this organization and to permit it to "cover" its property most effectively. Efficiency of "coverage" in detection and suppression was improved by 20 per cent. without increasing manpower requirements for 17,000,000 acres of the northern Rocky Mountain region.

Studies of minor phases of this "coverage" were made at several other experiment stations, McArdle and Byram originating a highly efficient eye test for lookouts; Buck and Fons taking the visibility problem into the laboratories of the California Station for investigation, and Show, Kotok and others recently summarizing all features of fire detection in California. Abell and Beeman and many others gave particular attention to visible area mapping, basic to lookout station selection and so important in providing adequate detection at minimum cost.

Thorough investigation of chemicals to aid in fire suppression, an obvious opportunity for research, has been commenced by the U. S. Forest Products Laboratory with the cooperation of several experiment station and administrative units. Results to date are promising for certain

A CORNER OF THE "FULL SUN" INFLAMMABILITY STATION AT THE PRIEST RIVER STATION. THE MAN'S RIGHT HAND POINTS TO THE WOOD CYLINDERS, HIS LEFT TO THE DUFF HYGROMETER SPIKE OF THE ANEMO-HYGROGRAPH, THE COVER OF WHICH HAS BEEN REMOVED TO SHOW THE CLOCK-DRIVEN WEEKLY CHART. OTHER TYPES AND SIZES OF WOOD CYLINDERS AND ONE OF THE FOUR LOGS USED IN STUDYING DISTRIBUTION OF MOISTURE IN WOOD ARE EVIDENT.

fuel types, negative for others. The elimination of glow, and consequent re-kindling, seems to be the chief attribute of chemicals.

Studies of fire breaks as one control measure to prevent the unimpeded spread of fires and to constitute a battle front from which to work have been largely confined to California, the Lake States and the Southeastern States. Chemicals for the permanent maintenance of fire breaks have been selected by the California Experiment Station, while the Lake States and Southern Forest Experiment Stations have made extensive tests of machine methods of fire break construction determining the principles of topographic location, width and depth of line and type of machinery.

FIRE DANGER METER

FIRE DANGER FACTOR MEASUREMENTS ARE INTEGRATED INTO NUMERICAL CLASSES OF DANGER BY USE OF A SMALL DEVICE CALLED A FIRE DANGER METER (IN MAN'S HAND). THE CURRENT TREND OF EACH FACTOR, OF DANGER CLASS, AND OF SIZE OF THE PROTECTION FORCE ON DUTY ARE PLOTTED DAILY ON A DANGER CHART AT MORE THAN 120 FOREST STATIONS IN THE NORTHERN ROCKY MOUNTAIN REGION. THE CHART ILLUSTRATED SHOWS A CASE OF POLICY OR FINANCES REDUCING THE PROTECTION FORCE EVEN THOUGH CURRENT DANGER HAD NOT DECREASED.

(4) Fire Damage

Thorough investigations of fire damage in the California region by Show and Kotok, the eastern and southeastern states by Abell, Harper, Lentz, McCarthy, Nelson, Osborne, Stickel and others, and by Mitchell in the Lake States have definitely demonstrated that the obscure and indirect forms of damage are even greater than anticipated by the National Program. The mere wounding of trees by fire not only depreciates butt-log values but eventually results in a high mortality due both to direct injury and to increased susceptibility to attack by insects and fungi. In the longleaf pine region of the South temporary but complete exclusion of fire has been found essential to satisfactory pine regeneration. Fires in turpentined stands of longleaf pine have been proven to be extremely damaging to gum yields and cupping materials. Indirect damages, such as water shortage, floods downstream from burned-over headwaters, and intangible or at least unassessable damages to recreation and wildlife or loss of labor markets in a community, due to the destruction of merchantable and near-merchantable timber, are not yet included as they should be in the so-called damage valuations.

(5) Fire as an Agent

Artificially induced but perfectly controlled fever has been recently recognized by the medical profession as a beneficial treatment for several human ailments. Well-controlled fire has likewise been found by several experiment stations to aid in the treatment of many forest ills. In both medicine and forestry accurate diagnosis and perfect control of the treatment are essential. The use of fire to immunize the forest against fire has long been advocated, but frequently the cure was more dangerous than the ailment.

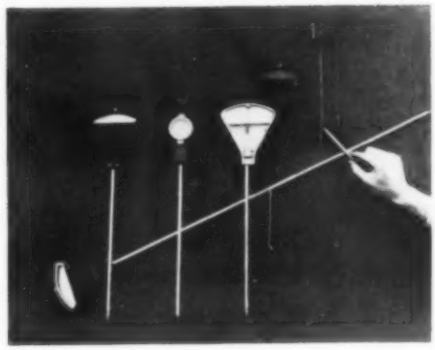
Scientifically controlled use has been found by research at the Southern Experiment Station, however, to aid certain forest types, (a) as a tree seedbed, (b) as a source of game and cattle forage and (c) in the reduction of some forms of disease. At the Lake States and Pacific Northwest Stations the beneficial uses of fire for fuel reduction have been weighed against the silvicultural damages, with the same conclusion as in the South, *i.e.*, fire should be used only by experts.

(6) Protection Standards

The National Program states that "the justification for fire research is primarily in its necessity for timber growing. Satisfactory timber crops cannot be grown unless certain definite standards or objectives of protection are attained."

Silcox[3] was among the first to state one protection standard as, "that system of fire protection which will hold the area burned-over each year to approximately one-tenth of one percent of the total" protected. Various other criteria such as percentage of class C fires, percentage of each timber type area burned annually and control by 10 A.M. of the next burning period have since been used as protection standards. None of these, however, is based intentionally upon all the social-economic objectives of forestry. None recognizes specifically the fact that forestry "works with folks as well as with trees and trails" and that "after all, folks are more important than firs." Since the National Program was written in 1926, the objectives of forestry have been greatly amplified, a beginning has been made in evaluating the social benefits of forest protection, the value of forest crops has been relatively minimized and the requirements of adequate fire control thereby very considerably expanded. This broadened concept of the functions of forest land management

[3] F. A. Silcox, *Jour. Agric.*, University of California, Vol. IV, No. 3, 100–101, 1916.



DUFF HYGROMETERS
INVENTED SPECIFICALLY TO MEASURE THE MOISTURE CONTENT OF DEAD TREE LEAVES AND TWIGS COVERING THE FOREST FLOOR. THE SENSITIVE ELEMENT IS A PIECE OF RATTAN (PENCIL POINTS TO ONE) EXPOSED INSIDE THE VENTILATED SPIKE OF THE INSTRUMENT.

constitutes a new basis for the determination of fire control standards which deserves immediate and intensive research.

Conclusion

As Bailey and Spoehr[4] have stated:

> All natural science is observational. During the earlier stages of its development, it concerned itself with describing and comparing the more obvious, complex, and grosser aggregates

[4] I. W. Bailey and H. A. Spoehr, "The Rôle of Research in the Development of Forestry in North America." P. ix. 118 pp. The Macmillan Company, New York. 1929.

AN ELECTRICAL METHOD
IS USED FOR MEASURING THE MOISTURE CONTENT AT VARIOUS DEPTHS AND ON ALL FOUR SIDES, TOP, BOTTOM, EAST AND WEST, IN LARGE LOGS.

of matter and units of energy. Through the analysis of large volumes of descriptive data, it succeeded in establishing many valid correlations between groups of phenomena. Subsequent search for actual causal relationships has led to the investigation of smaller and less complex aggregates or units, and natural science has resolved itself into a series of subdivisions, each of which deals with particular groups of phenomena and has developed its own specific observational technique.

Research in forest pyrology, that subdivision of forest protection devoted to protection from fire, has in the past few years identified and isolated many of its particular groups of phenomena; developed numerous specific techniques for measurement, analysis, integration and correlation; and has originated distinctive methods of immunization, detection, diagnosis and control fully comparable with those of many other recognized subdivisions of science. Forest pyrology is rapidly supplanting rule-of-thumb fire control and is now taking its proper place with the sciences of forest entomology and forest pathology for the better protection of our forest resources.

LIGNUM-VITAE, THE TREE OF LIFE

By Dr. JOHN C. GIFFORD

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Lignum-vitae—there is always an interest in, in fact, real history in a name. The "wood of life" and why? We apply it to the *live*-oak because it is continuously green and virile, but in the case of lignum-vitae it was so called because it was at one time considered one of the most valuable medicines in all the world. The gum of this wood has been in use since soon after the discovery of the New World, and its value as a medicine was, no doubt, learned from the Indians of the West Indies. The wood once sold for many dollars a pound. All the old medical books recommended it highly for gout, tonsilitis, neuralgia, rheumatism and syphilis. Now it is hardly mentioned.

Its generic name, ***Guaiacum***, with four vowels in a row, is said to be of Carib origin. The drug guaiac is obtained by soaking the sawdust and chips in alcohol. Tears form on the living tree where it is injured, and the oil can be secured by boiling the chips in water. The species found on the Florida Keys was named "sanctum" by Linné because he thought no doubt at that time that it was sacred, just as the Spaniards in the early days named cascara "sagrada." The latter drug still holds and is probably the commonest drug produced in the United States of North America, while lignum-vitae is now hardly mentioned in a modern materia medica. Perhaps it has virtue as a remedy. Many old things have, and it is hardly likely that it would have been used for so long a time without some results.

One of the keys of Florida is called Lignum-Vitae Key because this tree was once plentiful there. This key and Indian Key were used by Dr. Henry Perrine for his introductions into Florida over a century ago; in fact, Indian Key was reputed to be the first port of entry in South Florida. I have found lignum-vitae on Big Pine Key, Key Largo and other Keys, but this interesting and valuable tree is slowly passing. Although extremely hardy, like many other things when it starts to go it goes. In the battle with axe and fire any tree must produce an immense amount of seed in order to survive. In spite, however, of a constant demand a tree now and then may still be seen in secluded places. The wood is still

Photograph by Claude Matlack
TRUNK AND BARK OF LIGNUM-VITAE.

sold by the pound and is probably the most valuable of all commercial woods. Because of its toughness there is probably no wood with a greater variety of special peculiar uses. Aside from medicine its earliest use was in the manufacture of sheaths of ship-blocks. In the days of sailing vessels these blocks were essential, and we all know that for many years the woods by tidewater in Florida were used for ship construction by at least three nations, not to mention pirates and their kind that were outlaws. I have no doubt but that the tidewater timbers of Florida were exhausted more than once by people of many nationalities who came and went. Timbers of all kinds for ships must have been in demand for a long time. There must have been a feeling of scarcity, otherwise they would never have established a live-oak reservation at Santa Rosa near Pensacola over a century ago. Of all the special parts of a ship demanding special woods none was more important than the ship's blocks, through which the ropes could run easily and without the danger of breaking under stress.

Its modern use is of equal interest. The steel ship has superseded the wooden vessel. Propellers have replaced sails. What is now the most important use of this wood is for bushing-blocks for propeller shafts of ocean steamships. A wood must be tough to serve for such a purpose and the natural oil in the wood helps, although the constant turning of these great shafts under the water of the ocean millions of times in covering many thousand of miles is one of the most trying services to which wood or any substance could be subjected.

In the backwoods of Cuba many years ago I was shown a cannon of wood. The natives were short of materials of all kinds except what their patches of cleared land and the surrounding forest produced. They bored a hole in a lignum-vitae log. They wrapped this log with green rawhide. The hide in drying grew

tighter to help hold it together. They loaded it with bullets of some kind and black powder of their own manufacture. Although they assured me that it had been successfully fired several times, I did not wait for a demonstration.

To-day it serves for mallets, tenpin balls, castors for furniture, brush backs and a host of similar uses.

I have always admired this gnarled, round-headed tree. Its wood fibers are interlaced in such a way that it never splits. It is short and stout and appears in the shade in mixture with other things. It is of slow growth and is often found on very poor lime rock. The tree in some places looks as tough as its wood. It has a compound leaf three or four inches long with the leaflets arranged in three or four pairs. It is often fresh green when other things have been seared by drought. Three or four flowers are produced at the ends of the branches. They are under an inch in diameter but are delicate. The petals vary in shades of blue. It is a highly ornamental tree for the yard, and I have often thought that it would form a sturdy hedge. The fruit is roundish, less than an inch in diameter and usually bright orange when ripe. Inside are black seeds covered with a scarlet coat.

From the standpoint of use association through the years it has few, if any, peers. As a plant for future use in landscape architecture and forestry in the tropics it probably should have an important place. It is just one of those old-time trees in Florida which is slowly passing, unnoticed and unsung. Of course, over in the West Indies there are still many trees and it will probably be a long time before it is completely exhausted, but in the state of Florida it will soon be a thing of the past unless rescued by those who are interested in the preservation of native things.

Photograph by Claude Matlack

LIGNUM-VITAE TREES ON KEY LARGO.

Photograph by Claude Matlack

LEAVES AND FLOWER

OF LIGNUM-VITAE. ALSO SHOWS IMMATURE FRUITS.

AN UNWRITTEN CHAPTER IN THE PHYSIOLOGY OF AGEING

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THE information available to-day on the longevity and the causes of death in man, as well as in animals, indicates that the primary factor or factors in longevity are hereditary. That is to say, even if we had a total absence of infectious disease, an optimum diet and ideal conditions for life and work, and even if we knew how much and how little physical and mental work is the optimum for longevity, man and animals would still grow old, grow feeble and die. But there is no doubt that were ideal environmental and dietary conditions obtainable, man would reach a longer life span than he does at present.

There is also some evidence, both in the case of man and of other animals, that this hereditary time-clock or power of living varies considerably in the different organs of the individual, and since all organs are more or less necessary for living, the weakest organ becomes the weakest link and thus determines the life span of the individual. The primary hereditary nature of this organ time-clock is at present not readily differentiated from the factor of injury to individual organs by environment. The endocrine organs have by many been considered as such timers of the life span, and it is true that some of these, like the adrenals and the pancreas, if not the parathyroids, are absolutely necessary for life. It is a curious fact that the endocrines (the ovaries and the testes) that are by many laymen and many ill-informed physicians considered to be the primary time-clock of life and around which the whole pseudoscience of rejuvenation has been built up during the last generation, are apparently not one of the links that determine the life span of the individual. In other words, there is no evidence that early castration or spaying shortens the life span or that the life span can be prolonged by prolongation of the life of the gonads or by judicious administration of the hormones of these glands. Of course, it is well known that the gonads determine the level and duration of the period of life devoted to reproduction.

One of the important systems or links in the life chain is the heart and the circulation, and in the majority of people who live beyond 60 or 70 years, there is definite impairment of the heart and circulation, and death due to such impairments mount very high at this period. How much of this cardio-vascular failure in old age is the plain wearing-out of the hereditary machine and how much of it is due to the accidents of life, to infections, to faulty diet, to over-work or under-work, to emotional over-strain is still an unwritten chapter in biology and medicine, to which should be devoted well-planned and long-time research. In exceptional individuals living to the age of one hundred years or more, the vascular system at that period may still be adequate for the strain of life, and the cause of death may be an accidental infection of other systems, like the lungs. But this is the important consideration in connection with the heart and the circulation: This system determines the adequacy of the internal environment, that is, the blood in its relation to every tissue in the body. Consequently, any serious impairment or failure in the cardiovascular system will be reflected as an impairment of the activities of every organ in the body, including that of the

resistance to disease and the efficacy of the several immunity mechanisms.

Despite this primary hereditary time-clock of longevity as shown in plants, all species of animals, as well as man, there is no question that unfavorable environmental factors can themselves shorten the life span. Indeed, it may be true, but we can not at present assert it as a general fact, that part of the hereditary factors in longevity consist in the capacity to overcome, resist or adjust to unfavorable environmental factors. These unfavorable environmental factors may be classified largely in the following four groups:

(*a*) *Infections.* Some of these leave greater scars and impairments than others, but I know of no evidence to the effect that any infectious disease is favorable to longevity.

(*b*) *Diet.* We do not yet know what is the optimum diet for health and longevity at any age of man. But there is no question that quantitative and qualitative dietary deficiencies, if long continued, impair many organs of the body and therefore probably shorten life. And all the evidence we have to-day indicates that overeating and under-exercise, in the physical sense, are also injurious. To be sure, Professor McCay, of Cornell University, has in recent years shown that the life span of the white rat can be considerably prolonged when the animals are put early on a qualitatively adequate but quantitatively inadequate diet, so that their growth is retarded for one or two years. But we are not as yet justified in transferring these results on rats to the human species and keep our children retarded in growth until the age of thirty or thirty-five. McCay's experiments do tend to support the theory that the life span is determined in part by the rate of primary living, that is, the oxidative and the growth rates of the body.

(*c*) *Work.* As with the diet, we do not yet know what is the optimum mental and physical work for the most complete realization of the hereditary potentialities of longevity. No work at all seems to lead to adiposity and degeneration. Excessive physical work can apparently cause degeneration by exhaustion. But as we have, at least in the case of many of the organs, tremendous factors of safety, much physical and mental overstrain can be indulged in for very long periods before life is jeopardized. But this is largely an unwritten chapter. The chapter can not be written without further well-conceived and long-time research. From the point of view of society and civilization, work is more important than is longevity for the individual, and efficient life is more important than long life. I regard it high time that society concern itself seriously with research on this problem.

(*d*) *Poisons.* And lastly, we have the disturbing factors that may be briefly classified as the *poisons of civilization.* I don't refer to propaganda and hate and falsehoods and war. I refer to the actual chemical poisons of civilization. Our continued advance in chemistry, physics and engineering releases environmental conditions to which our forebears, primate and animal, were not subjected for millions of years. We have such things as alcohol in drinks, alkaloids in soft drinks, nicotine in tobacco, lead, arsenic, fluorine and other poisons on our vegetables and fruits, toxic chemicals in our canned foods, new and injurious chemicals blown into the air we respire by the smoke that goes up nearly every chimney of civilization. To-day we can recognize and diagnose and to a certain extent ameliorate acute and advanced chronic poisoning from such factors. But what injury to our living machinery is produced by these poisons of civilization before thus recognizable is one of the unsolved problems of medicine, society and government facing us to-day and to-morrow.

In brief, then, what is to be done about it?

The medical profession has its hands full, both to-day and to-morrow, in the matter of preventive medicine, in the way of prevention of infection, in prevention of dietary deficiencies and in prevention of over-strain, mental and physical. In this connection, we may note that an optimum environment is probably not attainable. The profession could and should take the lead in guiding society and government in the lines of research necessary for the wiser and healthier life of to-morrow.

The medical profession has a further duty in the line of education of our fellow men along the line of practical realism and understanding of the nature of life and disease. Physicians stand accused of being the main agency in the present-day civilization of preserving unfit human beings. Maybe they should pay a little more attention in the direction of better environment for those best fitted by heredity. At present a discussion of eugenics is largely academic. Society is not ready for it. We probably do not know enough to enforce the principles wisely, but there seems little doubt that eugenics could and should eliminate reproduction in individuals with the weakest hereditary time-clocks in their make-ups.

HIGH BLOOD PRESSURE

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What is this thing called "high blood pressure"? The term lies glibly on many tongues. Business men discuss it at lunch or in the club locker rooms; women tell of their blood pressure at bridge or sewing circles. A fascinating subject, made even more alluring by unconscious and misleading superficiality, for almost all the "facts" and fancies discussed are woefully wrong. The most ponderous oracular utterances by the elder at the club may be impressive, but they fail utterly to approach the truth of the matter. There are more false notions in the air than birds. Even among physicians there is a deplorable lack of understanding of the many aspects and problems of hypertension, popularly called high blood pressure. It is sadly true that our knowledge is still incomplete, but we can, at least, set straight that which is known.

America has become blood pressure conscious through its pocketbook. If the approach to a man's heart is through his stomach, then certainly the approach to the American mind is via its wallet. The one thing, more than any other, which drives home the importance, if not the significance, of high blood pressure to a business man is his rejection as a risk for life insurance. And life insurance companies are tightening their requirements and becoming increasingly unrelenting in these rejections. Of all diseases to which adult man is heir, the "cardio-vascular-renal diseases" (namely, that group including heart exhaustion and diseases of the arteries and kidneys) are the most frequent cause of death to-day. Heart disease is very often but a part of a generalized disturbance of which high blood pressure is the major warning. Sanitation and preventive medicine have done much to advance life expectancy, and as a result the illnesses and disturbances of middle and later life are of constantly increasing frequency. With every child saved from typhoid fever, "summer complaint" or diphtheria there is another adult potentially a victim for these later disturbances. Census data reveal a gradual but appreciable shift in the average age of our population to-

ward the older age groups; there are proportionately more people of 50 years or more now than there ever were before. The rapid pace of present-day civilization, the augmented complexity of existence and the anxieties of the competitive struggle to find security in a rapidly changing experimental social structure emphatically contribute to the excessive wear and tear so responsible for many premature deaths.

But the true tragedy of hypertension lies not alone in its frequency, not in its silent insidiousness nor in its ultimately high mortality, but in its misfortunate selection of victims.

The incidence of hypertension is increasing. It is difficult to determine accurately. In American males under forty-five years of age the incidence of hypertensive disease is in the neighborhood of 8 to 10 per cent. Above this age the frequency rises sharply for both sexes, so that in the sixth decade the frequency is of the order of 30 per cent. of the population. Hypertensive disease is characteristically a disease of those whose energy, productive imagination and sense of responsibility make them most valued citizens. In an age where more than ever before the fundamental and irrevocable laws of nature are being violated by gallantly chivalrous and politically motivated paternalistic aid for the relatively unfit, the survival of the spiritually, intellectually and physically fit becomes increasingly jeopardized. The workers shall labor for the drones. A wise policy, perhaps, in a community of bees or ants, but archaically naive and stupidly short-sighted in a civilization composed of presumably thinking men. The deliberate and consciously induced disrespect for the wisdom and experience of age gives the fresh impetus to the arrogance of ignorance and violence to the demands of short-sighted selfishness. Witness the almost incredibly rapid spread of the insolent phrase "the nine old men" and the truly vicious teaching of the implied disrespect.

Hypertension, although most frequent among the true aristocracy of doers and givers-to-humanity, is not limited to any one class of men. It appears, increasingly, in all walks of life. The free clinics and dispensaries of our large medical centers are overburdened with derelicts, incapable of work if it were available, whose disability arises from high blood pressure. Although more frequent and usually more rapidly progressive in men, it is a common problem in women, particularly at or after their "change of life." Hypertension is a most vital problem in pregnancy and is never to be taken lightly; it is a part of those poisonings of pregnancy which cause about one fifth of all our maternal deaths.

The mortality of hypertensive disease is high, although the course of the disease is usually slow and silent over a period of many years. Conservative estimates place the annual number of deaths in the United States, from this one cause alone, at over 150,000. Although numerous persons with hypertension live many years in apparent health, the average life expectancy is greatly shortened. The disability attributable to this silent and unobtrusive assistant to the Great Reaper is even greater cause for our concern. Many patients with high blood pressure live for years as partial or total invalids, a burden to themselves and to those about them, and with the threat of sudden death ever before them. High blood pressure is responsible for the great majority of heart invalids over fifty years of age. Furthermore, approximately one fifth of the deaths result from apoplexy and many more patients have non-fatal but disabling strokes.

All this presents so truly alarming and pessimistic a picture that one is tempted to adopt a futile fatalism as the easiest way out. That would be utterly wrong.

There are other sides to the picture (as there *always* are and as can always be found by conscientious search for truth, except by misguided zealots with preconceived notions, who must close their eyes and minds to all which does not coincide with their fancies). The rate at which the disease progresses varies greatly in different individuals. Its course, even when neglected, is painless and often so slow that it progresses over twenty years or more before tragedy intervenes. If discovered relatively early, hypertensive disease can usually be controlled and thorough and competent medical guidance can add many useful, happy years to the span of life. It is the very painlessness of the disorder which makes it dangerous, for it encourages neglect and postponement of the careful study necessary for effectual medical management. Then, when it is too late, when the damage done is irrevocable and irreparable, the patients expect, nay, even often demand, that the physician casually shake a miracle from his sleeve!

But, you may well ask, what *is* high blood pressure? How does it come about? Why does it occur? Are all instances similar? How does it cause damage? What are its consequences? What can one do about it and how effective is this doing? We shall try, within the limits of a non-technical exposition, to attempt to answer some, if not all, of these questions and disabuse the vague, misleading and semi-superstitious misconceptions now so prevalent.

Firstly, let us correct the most common fallacy. High blood pressure is *not* the result of "too much blood." The tenacity with which this untrue idea is retained in the popular mind probably relates by association to the ancient but misguided treatment by bloodletting. Although hypertension is by no means a "new" disease, its recognition is relatively recent. It is only since about 1900 that practical, simple and accurate methods of measuring the blood pressure in man were contrived. About seventy years earlier the first more clumsy and incomplete instruments were devised. As knowledge concerning the mechanisms of the circulation gradually accumulates and truth slowly comes out of darkness, it is realized that much of the previously acquired "information" is false and misleading and must be discarded and a fresh start made. It is not easy to unlearn errors. It can be said that the data and ideas concerning hypertension which antedate 1905 are largely valueless; almost all our present understanding has been arrived at in the last thirty years, and to-day, as always, these concepts are in a continuous state of flux and revision. What we use as true to-day may be proved wrong to-morrow. But in the meantime we must *use* these tentative truths as tools to make better ones.

To outline the mechanisms of hypertension, or high blood pressure, it is necessary first to explain briefly something of the normal processes of the circulation. Disease does not involve new processes, but exaggeration or distortion of the normal mechanisms. The purpose of the circulation is to supply all the cells of all the tissues of the body with food, building material and fuel. The fuel is oxygen, taken up by the blood in the myriad of air saclets of the lungs, and food materials from the intestinal canal. In order to reach all the cells, these final, finest delivery channels or vessels must be extremely small and ramify in a close meshwork so that no one cell of the body is at any great distance from a vessel. Such minute ducts are called "capillaries" and correspond to the by-streets, alleys, courts, passages, water pipes and sewers of a colossally gigantic city so that each and every "inhabitant" thereof may receive his share of nutriment and get rid of the garbage of his existence. Just how many million miles of these minute vessels exist in a man has never

been computed. Of necessity the walls of the capillaries are exceedingly thin to permit of ready and rapid transfer of oxygen and food from the blood to the cells and *vice versa,* transfer of debris from the cells to the blood.

Between these tiny, microscopic channels and the larger, visible, thick, pulsating arteries such as those we may feel at our wrist and which may be compared with "ultra superhighways" of the colossal community of cells, there are many, many miles of "through streets" or "arterial highways" whose average size is such that from 400 to 800 of them side by side would be an inch thick. These are called "arterioles" or little arteries. The arterioles serve several purposes, each vitally essential to the body. Their walls are relatively much thicker than those of the capillaries. The walls are largely composed of muscle cells which lie wrapped about the bore of the vessel in close spiral formation. These muscle cells resist stretching and therefore give strength to the vessel walls, and they also may contract, narrowing the bore of the tube.

The arterioles have, in addition to the usual function of being smooth ducts to carry the blood, two fundamentally important activities. They interpose a dam between the indispensably higher pressure and rapid flow of blood in the arteries and the low tension and necessarily leisurely movement of the blood in the swamp-like channels of the capillaries. Behind this dam of arterioles the pressure of the blood is considerable, below it low. Therefore, they are a potent force in maintaining the arterial pressure and in preventing collapse of the circulation.

It becomes obvious how inadequate is the term "blood pressure," for at different levels of the circulatory tree the pressures are different. We can and should speak and think of "capillary pressure," "arterial pressure" or "arterial tension" and "venous pressure," to be clearly precise. The terms "blood pressure" and "high or low blood pressure" have, by usage, been used to designate the arterial tension, but such usage is loose, confusing and undesirable. To maintain a normal and adequate circulation in the capillaries is the prime motive of all the rest of the circulatory machinery, and to do this a sufficient head of pressure in the arteries is necessary. This head of pressure is sustained by the propulsive force of the heart on the one side and the peripheral resistance offered by the minute spiral muscle cells in the walls of the arterioles on the other. Other factors enter into this conflict of forces, but they need not concern us here. Death quickly intervenes if the tension is not maintained. To say "Have I a blood pressure?" is as ridiculous as to ask, "Must I breathe?" It is only when the pressure becomes abnormally high or abnormally low that it becomes a menace.

The second auxiliary function of the arterioles is *to control the distribution of the blood.* The demand for blood on the part of the cells is not a constant requirement, but varies with the amount of work being done. For example, after a meal there is a greatly increased demand for blood in the organs of digestion; with walking or running the leg muscles require many times the amount of oxygen they use at rest, or on thinking the brain consumes much larger quantities than during sleep. These perfectly normal fluctuations or "rush hours" are taken care of by the arterioles: during digestion the vessels in the stomach and intestines relax and the flow of blood through the capillaries is greatly increased. As this happens there occurs a compensatory constriction of the arterioles elsewhere in the body and the circulation as a whole is but little disturbed. As the "rush hour" of digestion demands an appreciably larger share of the supply of blood, other structures must get less at that time. This explains the drowsiness which comes over us after a hearty meal or the inability to

exert violently during digestion. To attempt severe mental or physical work during digestion invites inefficiency for *both* the digestion and mental or muscular activity.

Thus the arterioles are in a constant state of variation and adjustment of the blood flow, both locally and generally. Their muscular walls are continually relaxing or constricting slightly to maintain an equitable distribution of blood to the tissues. The tone or degree of tension in the spirally arranged smooth muscle cells of the arteriolar walls is under the control of a complex meshwork of automatic nerves. There is no conscious control of the vascular tone, nor any consciousness of the state of tension within the vessels. Thus it is possible that an individual may be walking about with a blood pressure of twice the normal and still not be conscious of it.

Of the almost innumerable illustrations of arteriolar activity which might be cited, two will suffice. The old-fashioned blush is nothing more or less than a temporary relaxation of the arterioles of the face and neck so that there is a transient increase in the flow of blood under the skin and hence the red hue. Blanching on exposure of the skin to cold is its converse. The "angry red" zone about a localized infection such as a pimple or small boil is due to arteriolar relaxation in that area; this fulfills the purpose of bringing more blood to combat the invading bacteria. In both these illustrations the change in caliber of the arterioles occurs in limited areas and because of the balancing constriction of arterioles elsewhere in the body there is little or no appreciable change in the general circulation; the blood pressure is unaltered.

Increase in the blood pressure *arises from a generalized increase in the tone or constriction of myriads of arterioles.* In the development of the disease of which increased blood pressure is the major and characteristic change, there is, at first, a gradual and intermittent increase in arteriolar tone. As the arterioles constrict slightly the blood flow in the capillaries is diminished and, simultaneously, the resistance to the flow of blood from the arteries is increased. It is as though there were a partial closing of the sluice gates of a dam. So, *behind* the arterioles the circulation is lowered. The greater the constriction or obstruction the higher the arterial pressure and, what is more important, the poorer the flow of blood in the tiny but life-sustaining capillary networks.

As hypertension first develops, the constriction of the arterioles is intermittent and variable; the blood pressure frequently is quite normal but rises to higher levels temporarily. It is normal that the blood pressure vary under certain circumstances such as anger, effort, fear and the like, but in these individuals the rise is exaggerated. These more violent fluctuations are extremely important; they forewarn that in the future the pressure will tend to remain at higher levels and that the temporary ascensions will become greater and greater. We can now see why a single, isolated observation of the blood pressure can be dangerously misleading; neither a single normal reading nor a single observation of elevated tension is significant until we know what the average and habitual behavior of the blood pressure is under varying circumstances. It is as though we were to conclude that the pulse is perfectly normal because it is found so after an hour's nap; after exertion or excitement it might behave most outrageously.

With the passage of time the increased tone of the arterioles becomes more and more continuous; the minute muscle cells are more and more constantly contracted and the caliber of the arterioles persistently narrowed. Now the blood pressure is more unceasingly elevated. Struc-

tural changes in the arterioles begin to take place. Use stimulates tissues to grow. Exercise causes greater development of muscle. Thus the arteriolar walls gradually become thickened by growth of the tiny muscle cells; they become both larger and more numerous. As the arteriolar walls become stronger their ability and tendency to constrict becomes greater, so that the increase in tone is further enhanced. A vicious circle is engendered. The arterioles are now constantly somewhat narrowed and at the slightest excuse they contract still further. Thus the blood pressure is continuously increased but subject to acute and often rather violent fluctuations still further upward.

But it is characteristic of muscle cells that they are not adapted to continuous contraction. Muscles function efficiently only when their contraction is intermittent. This is quickly demonstrated by the difficulty encountered on holding one's arm horizontally for any length of time; fatigue quickly ensues. Whereas one may lift and lower the arm many times without exhaustion, continuous elevation soon becomes irksome because of muscle weariness. The continuousness of the arteriolar contraction gradually and almost imperceptibly causes fatigue and then exhaustion of the muscle cells. As this continues, a few muscle cells in the arteriolar walls become exhausted and die. Their places are taken by scar tissue. This scar tissue is neither elastic nor does it have the power to contract as does muscle. The tiny arterioles become stiffened and narrowed; the blood pressure is continuously raised to high levels because of this obstructive narrowing of the sluice gates. This latter type of change in the arteries (arteriolarsclerosis) is permanent and irrevocable.

This then is what happens with long-continued high blood pressure. The whole progression takes years to develop to the point where the scarring of the arterioles is advanced and unchangeable. It may be twenty or more years from the beginning of the disturbance; in some few especially violent and rapidly advancing cases but one to three years elapse. All grades of severity and rates of progression are found. The almost imperceptibly slow march of events is tenaciously persistent. There is no tendency toward arrest of the advance. It is free from pain throughout. Usually there is no consciousness of any appreciable change.

Why then be concerned with efforts to arrest the progress of this silent, painless disease which is so harmless in the early stages? Because it is *only* in the early stages that anything can be accomplished, and because, when the damage is done to the vessels, the patient is in constant jeopardy. It is then too late to perform miracles. Thus the very essence of the problem is early discovery, early treatment to arrest advance and prevent or, at least, greatly postpone, the ultimate, inevitable termination.

Recalling, for a moment, the description of what bodily changes take place to create an increase in the blood pressure, we are conscious of the disintegration of certain popular myths and false ideas. Firstly, it is clear that thickening of the arterioles is less the cause of high blood pressure than the result thereof. Secondly, the disease is not one of the blood, but of the arteries and arterioles. Hypertension is not the disease; it is a *symptom* or sign of the affection of the vessels. The term "hypertensive arterial disease" is particularly apt. It is of great importance, for the sake of clarity, to distinguish the one from the other; they are much confused even among physicians. Hypertension, or the state of high blood pressure, may exist without the disease, under conditions of temporary arteriolar constriction. The disease

develops only after the increased tension of the vessels has continued long enough to induce the aforementioned changes therein.

Thirdly, it becomes evident why early in the course of the disorder the blood pressure is extremely variable (during those phases where the arteriolar muscle is growing under the impetus of increased activity) and quite "fixed" later when scarring of the vessels has occurred. The "fixedness" of the blood pressure is a better guide to the condition of the vessels (the essential question) than the mere height of a single measurement. It may be a most desirable omen that the blood pressure fluctuates widely.

Fourthly, we have seen that a great deal depends upon the character and quality of the arterioles. It was in this connection that the great Sir William Osler used the expression, "the quality of the rubber." The toughness of this arteriolar "rubber" to withstand the repeated shocks and insults of existence and the increased burden imposed by hypertension largely determines how long it will last. That the "rubber" is not all that it might be in instances of hypertensive arterial disease is shown by the fact that hypertension develops. That is in itself evidence of inherent weakness or vulnerability. This vulnerability takes the form of increased responsiveness to stimulation or irritation. Irritants which have little effect on normal persons cause exaggerated constriction of the arterioles in those "vulnerable" ones who develop hypertension. This susceptibility is inherent and permanent; it is as much part of these people as are the color of their eyes, their tastes or the shape of their hands. It is essential that this be kept in mind, because, although one may arrest the progression initiated by *one* source of irritation, that does not prevent recurrence of the disturbance from other sources. The vulnerability of these patients permits of frequent recurrences and exacerbations or "flare-ups" of the hypertension. It is as a turned ankle; more likely to be sprained again, even with relatively little insult.

Two of our questions are now answered. We've seen what high blood pressure is and how it comes about. But, *why does it occur?* That is not as readily explained. It is so easy to ask "what is the cause of high blood pressure?" and so difficult to give a scientifically satisfactory answer that most physicians shelve the whole problem by replying: "The cause is unknown." That is not true. Much, but by no means all, is known. In recent years there has been considerable progress made toward the solution of this vexing problem. Scientific progress is slow, and is the product of many minds and labors. Exploration into the unknown realms of science (and this applies not only to medicine and biology, but to all science), is a matter of cooperative effort by many workers, each taking but one step forward at the time; the combined steps into the gray void of ignorance slowly bring light thereto, and the unknown becomes clear. There are few whose vision penetrates far through the haze; nature's secrets are well guarded by a shrouding mist or fog and through this mist we must penetrate, checking and rechecking each slow forward step so that false assumptions may be avoided. That a few are gifted with penetrating vision to see far through the haze and open whole new continents of thought and knowledge is the inspiration of the many workers. Darwin was one such; Pasteur another. To venture into the realm of the scientific unknown is to combat fog. Fog is the occasional lot of the geographic explorer; in other forms it is the usual and habitual handicap of the biologist. Fog is all-enveloping, gray, almost impenetrable, distorting distance and size and shape. The infinite varia-

tion that occurs in life makes generalizations extremely hazardous.

It is false logic to assume that there is but one cause of high blood pressure. There are many. There always are. Events and consequences, be they disease of man, economic waves of lavish prosperity or desolate famine, wars, tyrannical exploitations of whole nations or the petty scandals of the crossroads, result from the interaction of many forces, some recent, some passed, some apparent, even obvious, and others, darkly obscure. To deny the existence of these forces which are obscure just because we, as yet, can not see them all, is worse than folly; it is prostitution of our heritage of intelligence.

Hypertension may be likened to the breaking of the camel's back. The fable says it was the last straw which broke its back, ignoring the equally important weight of all the other straws! And the previous load may not have been straw at all, but bricks or hay or dates! To understand the "why" of disease (and certainly a broken back is a major illness) the first essential is to recognize the infinite possibilities of multiple insults and that each and every example may have a different set of injurious factors.

Many of the causative factors responsible for high blood pressure are known. They fall into three categories—predisposing, provoking and perpetuating factors. This classification of causative influences is applicable to any disease. For example, although we know that influenza is "due to an infection" we also have come to realize that even more significant is the depletion of the patient's resistance through fatigue, exposure, anemia and the like, prior to the exposure to the microbes. It is this depletion of resistance which makes possible the invasion by the infecting agent. Or, we may take as an example the problem of flood control; if the dykes or levees are in good repair no flood will occur unless the rise in the water is extraordinarily high, whereas a small rise in level will cause floods if the dyked banks are weakened through neglect.

In hypertension the predisposing factors are of the greatest importance. To repeat Sir William Osler's quotation, much depends upon "the quality of the rubber." The hereditary and familial background determines this. Hypertensive arterial disease frequently "runs in families." It is not implied that the disease itself is transmitted by heredity: the vulnerability is inherited. That is why physicians take the pains to inquire into the "family history" despite the usual incompleteness and inaccuracy of such information. Most of us are woefully ignorant of the medical aspect of our family background. I wonder how many of us can accurately state the cause of death of all four of our grand-parents. I know that among my medical students only about 10 per cent. can answer that question. And yet that represents but two generations back. Breeders of fine animals know all too well how inadequate such brief genetic history would be in developing superior stock. The absence of known evidence of arterial disease is no proof of absence of the disease. Negative evidence is never proof. Because John can't find his collar button does not prove the collar button doesn't exist.

Personality has considerable bearing upon the occurrence of high blood pressure. Nervous control of the arterioles, although automatic and not under conscious or "voluntary" control, is markedly affected by the status of the higher nervous centers. Fatigue is a curious two-edged phenomenon; it may depress as it approaches exhaustion or it may stimulate by reducing the affectiveness of a balancing mechanism. It is most difficult to appraise fatigue of the nervous system.

The hypertensive individual frequently conforms to a characteristic personality

pattern. It is extraordinarily perplexing as to whether certain psychic characteristics are responsible for the development of hypertensive arterial disease or are a result thereof. Probably both relationships are true. The typical hypertensive personality is aggressive, enthusiastic and active. These people are doers, are forceful and restlessly ambitious. They tend to work continuously, knowing not the value of mental relaxation, for they are obsessed with a conspicuous singleness of purpose. Absorbing hobbies are shunned as being "a waste of time" rather than being recognized as valuable. Games are taken seriously and with the typically American intensely combative spirit of competition. Frequently the ardent will to win leads to eminent success in their chosen careers, but this is accomplished at an extravagant cost in physical depletion. These personalities resent inactivity and delay; calm adaptation to the irritations of existence is replaced by a shortened, explosive but effervescent temper. Whenever things go wrong they must "*do* something." Characteristically, they are keenly conscious of responsibilities and appear to seek additional burdens. They are temperamentally "habitual worriers"; this is the most common trait. They are not truly pessimistic nor tranquilly fatalistic.

The most significant and frequent characteristics are the tendency to habitual worry, the increased consciousness of responsibilities, the consuming anxiety for success and the inability to relax. It is consequential that all these outstanding psychic traits contribute to fatigue. Such fatigue of the nervous system may be a potent factor both in predisposing toward hypertension and in the perpetuation of the processes in constitutionally vulnerable individuals.

There are countless provoking factors which may start the arteriolar constriction of hypertensive disease. The initiating factors include "anything which, over a long period of time, irritates or stimulates the arterioles." Such an inclusive statement requires amplification. Almost invariably there are several super-imposed sources of injury to the arterioles. Each and every case of hypertensive disease presents a new and individual problem in finding the causative influences. We know of many of these factors, but not all. Therefore, it comes about that occasionally one must, even after careful study, admit that the cause is undiscovered. But that does *not*, as so many defeatists declare, imply that there is no cause.

The known provoking factors group themselves into several categories: Infectious factors, chemical poisonings from without, chemical poisonings from within and nervous factors. Among the infective factors two stand out preeminently. There are influenza and long-neglected foci of infection such as at the roots of teeth, in tonsil stubs, chronic sinus infection and the like. In such instances it is not so much the intensity of the infection as its long duration which is important. Influenza or la grippe is a treacherous and misleading malady. Its most characteristic attribute is that its sequelae or "hangovers" are all out of proportion to the apparent severity of the acute illness. A few days of seemingly mild "flu," with perhaps but 48 hours of fever, is followed by four to eight weeks of both mental and physical lassitude and weakness. As one patient put it to me: "The limp dish-rag feeling." These are but the obvious consequences of "flu"; far more important are the silent, insidious injuries to the vital structures such as the heart, kidneys or blood vessels. Here again the physician is frequently led astray by unintentional misinformation; the hypertensive patient has sincerely forgotten, and thus failed to mention, the "mild" attack of "flu" which laid him abed for three or four days some

years previously. And such latent injury is far more likely to those of the hypertensive personality; their restless ambition is so short-sighted that it does not permit them to take adequate time for convalescence and repair after an acute infection.

Among the chemical sources of injury to the arterioles are lead and arsenic. Mild degrees of chronic lead poisoning are far more common than is generally realized. It is not limited to industrial workers. Unwise dietary habits may play a role; particularly significant are the abuse of condiments and spices and an habitually insufficient intake of water. The "hot" oils of the spices which burn our tongue also irritate the arterioles and the kidneys, although we don't feel their smarting there. The highest arterial tension I observed (360 millimeters of mercury) occurred in a young woman who had, for several years, consumed two to four bottles of Worcestershire sauce per day, undiluted. She liked it, but it contributed to her most untimely end. Other dietary factors are less important but may contribute if far out of line with the normal balanced ration. Alcohol is rarely a factor. In a few instances tobacco may be productive of arteriolar irritation, in certain susceptible individuals. The susceptibility to tobacco smoke is extremely variable.

Illustrative of chemical injuries arising from within are certain distortions of the glands of internal secretion (high blood pressure arising at the change of life in women is quite frequent), the poisonings associated with kidney injury, the chemical imbalance that may accompany pregnancy and last, but not least, fatigue. Fatigue should be considered as much a poisoning or intoxication as inebriation, only it is hidden both from the sufferer and those about him. Long-continued nervous and physical fatigue in conscientious individuals, continuously and keenly conscious of their many responsibilities, is a factor which can not be ignored. Thus it is that so frequently those who carry the greatest burdens of a community's welfare succumb to high blood pressure.

Kidney injury usually produces no symptoms which warn the patient that these vital structures are failing to do their work properly. Even examination of the urine may be unsuccessful in revealing the extent of damage. We start life with a wide margin of safety in kidney capacity to rid the body of noxious substances; this extra reserve is gradually reduced as we go through life, sometimes slowly, sometimes rapidly. Just because it is the major function of the kidneys to rid the body of excesses of chemically injurious substances, these structures are particularly exposed to injury. Acute infections frequently cause undetected kidney impairment; the acute contagious diseases such as scarlet fever, diphtheria and the like are the most common sources of silent damage in youth. Such damage may exist for years without sufficient manifestations to drive the patient to a physician; then, in the years usually classed as the prime of life, the kidneys fail utterly and life is but a matter of months. Injury to the kidneys from any source is one of the frequent provoking factors in the causation of high blood pressure. Detection of such injury and measurement of its extent and significance requires careful, thorough, painstaking study by the physician. These are not questions which can be properly answered in a few minutes.

These are some of the reasons why high blood pressure arises. It is obvious that each and every instance of the disease is an individual problem and requires individual study and attention.

Hypertensive arterial disease causes damage by interfering with the normal and required supply of blood to the tis-

sues of the body. The narrowed arterioles do not permit sufficient blood to pass the sluice gates of the dam to provide adequately all the needs of the tissue cells. The early changes are but exaggerations of the normal activities of the arterioles and are intermittent. At first this interference causes little or no disturbance and there are no resultant symptoms. Later, often only after some years, when the constriction of the regulatory arterioles is continuous, evidence of such circulatory deficiency is to be found. But the evidence or symptoms are *not* directly referable to the vessels or to the high blood pressure; they are referable to the inability of certain tissue cells to do their work properly. Thus the symptoms which arise late in the course of the disease (and it can not be over-emphasized that early there are no symptoms) differ greatly in different individuals. The character of the symptoms depends upon the site, extent and abruptness of the local failure in blood distribution. In some the brain will suffer from the inefficiency of the circulation, in others the kidneys, the eyes or the heart. Thus the symptoms will be as legion in their patterns as are the cases.

The requirements of cells for oxygen depend upon how much work they are asked to perform. The muscles of the leg, for example, require at least ten times more oxygen when a man is running than when he is standing. The deficiency in oxygen supply (or blood supply, for the one depends upon the other) first becomes manifest under conditions of stress or increased activity. All structures in the body have a large reserve capacity to meet unusual demands; depreciation of this reserve is gradual and often almost imperceptible. Evidence of failure does not occur until the capacity to work is actually less than the requirements.

Heart failure accounts for from 50 to 60 per cent. of deaths attributable to high blood pressure. Such failure may be of several forms, abrupt or gradual, but that does not concern us here. Some damage to the heart in high blood pressure is inevitable. Heart injury is the gravest risk to the hypertensive. Hypertension presents a triple threat attack upon the heart. First, the heart muscle suffers when its own supply of blood in the walls of the heart is interfered with by arteriolar disease. Second, the heart is the one structure constantly required to carry an increased burden of work; as the resistance to the free flow of blood increases (resistance offered by the narrowed arterioles throughout the body) it must work harder and harder to overcome this. Third, the heart is a blood vessel and therefore vulnerable to the same sources of injury as the arteries. The factor of increased work under adverse conditions is most significant. During rest the normal adult heart moves some ten tons of blood per twenty-four hours. This is merely the weight or volume of blood moved and does not take into consideration the resistance to the free movement of the blood. Increased resistance may double the amount of work involved. Thus the heart is working as though the man were climbing stairs constantly—day and night—and doing this with a collar so tight that it is hard to breathe. It is not surprising that the heart wears out prematurely.

The depreciation of the heart's vigor and reserve is at first so gradual and painless that it is usually ignored by the patient. Through centuries of struggle we have come to recognize pain as a warning: so much so that automatically and reflexly we cease doing anything if it hurts to continue. But pain is almost the only warning which we heed; with ostrich-like blindness we try to "explain" other forms of distress or warnings as being insignificant, closing our eyes to the implication that following such warnings is our best protection against disaster. The

motor car has brought us the green, amber and red lights. We must learn to heed these warning lights if we wish to survive long in the chaotic traffic of modern existence.

What are the "lights" with which the heart cautions us to "go slow" or to "stop"? There are several, but the most frequent and important one is breathlessness. Now, breathlessness on exertion is a perfectly normal phenomenon *if the exertion is sufficiently strenuous!* For the runner, after a hundred-yard dash, to pant is normal because his muscles have used up more oxygen than his lungs, heart and circulation can supply in the ten seconds of violent exertion. He has borrowed, created an "oxygen deficit" by extreme expenditure in the intense effort of the race. Not even the normal circulation can supply the oxygen demanded at the moment. But the debt must be paid and promptly. Therefore the panting, sobbing, deep breathing which follows. Here we have one example of the liberal credit structure with which nature endows us. We can "borrow" against the future in many ways ("running on one's nerve," using drug stimulants such as caffeine to carry on despite the warnings of fatigue, burning the fuel of tissues, later to be replaced with food, are other illustrations of biologic borrowing), *but the debt must always be repaid.* Herein nature's laws are sane; no "New Deal" legislation can postpone the day of payment.

Breathlessness becomes an amber light, warning us to "proceed with caution" when it appears upon less and less effort. It is not the breathlessness or panting which is so significant *but the degree of effort necessary to induce it!* The man on the street, the banker at his desk, the obese matron nibbling chocolates at a matinee, the business man puffing up the hills on the golf course "for business reasons" all attribute their increasing "shortness of wind" to something else than heart depreciation. "Too many cigarettes," "indigestion," "didn't sleep well last night," "worry" or "getting a little soft now" are some of the innumerable soothing syrups with which self-delusion is continued. Let us not criticize; it is human nature to resent the depreciation of the years, particularly if conceit and ambition make us feel important to the world. The plaintive rebellion of self-esteem against restraint is: "Slow down? I can't. My business needs me." None of us are *that* important to others; only to ourselves do we appear so. Triteness alters not the fundamental truths, and repetition of the ancient axioms that "haste makes waste" or "make haste slowly" falls upon ears deafened by the roar of the city.

More can be accomplished leisurely than in haste. The artist knows this. So does the true teacher. The grubber for money does not. Let us recall that we live but once and must expect to remain dead a very long time. Alfred Stieglitz, the artist, once thought of his own epitaph while in the dentist's chair: "I have lived for better and for worse, but I am dead for good."

The warning of breathlessness on less and less effort comes gradually. Hypertension and heart depreciation do not at once imply immediate jeopardy. Nor do they denote invalidism. High blood pressure is in itself not particularly dangerous. We have tried to explain this. Its risks are in the future. The progression of the disease is slow; years elapse before the changes become irrevocable and the danger of disaster is great. But for all the slowness of this depreciation, it is inevitable and persistent. There is always the potentiality of acceleration of the degenerative process; acute infections, fatigue, continued worry, intoxications of any sort may quicken the rate of depreciation at any time and thus bring closer the ultimate, inevitable failure. There is no tendency toward spontaneous improvement or cure. Ignoring the existence of

the threat of high blood pressure, while perhaps stupidly reassuring the apprehensions of the patient, accomplishes nothing else.

The objectives of treatment are to prevent, or at least postpone, the future difficulties and disasters of heart failure, apoplexy or kidney failure. An attitude of prevention is essential. High blood pressure is a controllable disorder, but it is not a problem which can be treated for a few weeks and then wholly forgotten. The likelihood of recurrences and flare-ups is an ever-present menace, and observation and guidance must be continued. To be precise, we should say hypertension is controllable rather than curable.

It is impossible and inappropriate to attempt to discuss treatment here, but certain aspects of the broad problem warrant mention. As *prevention* is the primary objective, *early detection* of the disorder is the first step. Failure to start treatment during the early stages of the disorder tremendously increases the difficulties of management later on. As previously mentioned, it is when irrevocable damage has occurred that patients expect a miracle. The responsibility for health rests first and foremost upon the individual; a physician can accomplish nothing unless the patient cooperates. So many take the infantile attitude that in following advice they are doing it for the doctor, forgetting that it is for *their* benefit, not his, that the advice was given. This attitude is exceptionally prevalent among hypertensive individuals; they feel well and are often unusually energetic. They deeply resent the implication that they are not well. This blindness, which is part of the combative personality of hypertension, is a real handicap to the intelligent physician trying to postpone future disasters.

The earlier the disorder is detected and management instituted the better are the chances of accomplishing the objectives of prolonging life and health to its normal span. As high blood pressure is usually unaccompanied by symptoms which call it to the attention of the victim (at least, not early in the course of the disease) it is necessary to search for it. Determination of the blood pressure is a simple safe quick procedure, free of discomfort. It is a matter of but a few moments. Periodic inventory of one's physical condition is the answer to the problem of early detection of disease and its corollary, successful control. It is extraordinary how well we treat our automobiles and how shabbily we treat our bodies. We don't hesitate to run in to the service department of the car dealer to "tune the motor" or "check the brakes" or complain of this or that, but how few will trouble to see if their own motor is behaving quite as it should. Banks balance their books daily, the merchant takes periodic inventory of his stock, the manufacturer constantly inspects not only his product but his equipment, and yet ignores his most precious investment—his health.

Periodic health inventory should be at least an annual event when all is apparently normal. To be of value it must be thorough. No public accountant can analyze the books of a year's business in a few minutes; remember that *your* body is a complex "business." Give your physician the opportunity to be thorough in his search for facts upon which to base his decisions and advice. That advice may have far-reaching consequences. If evidences of illness are found, recheck at much more frequent intervals than twelve months is, of course, in order. Such evidences may be more indicative of potential illness than of actual existing disease. It is possible now, with the aid of a simple but effective test procedure, to determine potentiality to high blood pressure even before it occurs. This is done by observing the response of the

blood pressure to a standard stimulant such as cold. Even in children the test has revealed the inherited tendency to be vulnerable to arterial disease; comparison of the results of many tests on school children showed a conspicuous association between such warning responses and the presence of high blood pressure in one or both parents. Thus the patient with high blood pressure owes it to his or her children that they be guarded before it arises in them. In matters of health particularly the old adages "forewarned is forearmed" and "an ounce of prevention is worth a pound of cure" are basic, fundamental truths.

If the task of devising a suitable motto to be inscribed above the blackboards of schools were assigned to me, I should write "You will not find Truth unless you look for it."

As each instance of the disease presents a different problem from the viewpoint of *cause*, so each instance is an entirely individual problem in *treatment*. Individuality in treatment is essential. It is possible only after thorough, painstaking study of the patient, the reasons for his illness, the extent and duration thereof, the status of the heart and kidney reserve capacities and many other factors. The first principle of curative treatment is that it shall include consideration of the causes of an illness. To treat a sore heel due to a nail in a shoe accomplishes nothing unless the nail be removed. The second principle is that the injured structures (in this instance, the blood vessels, heart and kidneys particularly) shall have as much rest as possible so that they may do their own repairing with the least hindrance. Time is an essential ingredient of rest. Thirdly and lastly, treatment must consider the nutrition of the patient as a whole and of the injured part in particular. To illustrate this last principle we may cite the importance of correcting anemia, even of mild grade, in high blood pressure. Recalling that the damages done result from the inadequacy of blood flow to the tissue cells, we can at once see how tremendously this detriment is enhanced when the blood which does reach the cells is not up to par and is deficient in oxygen-carrying capacity. The double insult quadruples the injury.

Successful control, making possible many years of happy, vigorous and useful life, does not imply making an invalid out of the patient. That is almost always unnecessary. Temperance in all things, wise counsel, with the intelligent, occasional utilization of certain drugs, constitutes a type of approach which is most often eminently successful. An attitude of optimism is fully justified. The earlier recognition of the condition occurs, the better the outlook. The problem is one of treating the patient, not the disease.

GEOLOGICAL STORY OF THE GREAT LAKES

By the late **FRANK BURSLEY TAYLOR**
U. S. GEOLOGICAL SURVEY, 1900–1916

THE Great Lakes of North America—Lakes Superior, Michigan, Huron, Erie and Ontario—gave to our continent a distinction not enjoyed by any other, for no other has so many lakes of large size so closely connected and so well situated to serve the needs of man. While a very notable group of lakes occurs in Africa, only one—Lake Victoria—is of a size comparable to Lake Superior, and the whole group and its surroundings is in other ways very different from ours. Our lakes lie in the middle north latitudes, with a vast area of fertile plains stretching away to the south and west, where the soil and the prevailing climatic conditions favor the highest development of agriculture. This relation is fortunate for many reasons. It has been especially favorable not only for the growth of agriculture, but also for the development of water power and great industries, as is exemplified in several of our most populous and prosperous states. Rich stores of copper and iron lie near Lake Superior's shores and coal and petroleum near Lakes Huron and Erie. Lake Superior is nearly 400 miles long and averages about 90 miles wide. It is six hundred feet above the sea, while Lakes Michigan and Huron are twenty feet lower and Lake Erie is eight feet lower than Lake Huron. Lake Ontario is two hundred and forty-five feet above the sea. Lake Superior is one thousand feet deep, Lakes Michigan, Huron and Ontario between seven and eight hundred feet, while at its deepest spot Lake Erie is only a little more than two hundred feet deep.

The connecting rivers between the Great Lakes have all been made navigable and, with the lakes themselves, now constitute one of the greatest highways of commerce in the world. Ultimately, the whole group will be effectively connected with the Gulf of St. Lawrence and with the Hudson River and, through the Mississippi River, with the Gulf of Mexico. Fishing is a great industry on the lakes and yields a large supply of some of the finest food fishes known. The shores of the lakes are dotted with summer resorts, where each year thousands of people find relief in the heated season.

Thus, briefly, we may describe the Great Lakes as one sees them to-day. But to an inquiring mind, certain momentous questions press for answer, especially questions relating to the origin and history of the great rock-hewn valleys in which the lakes lie. How were they formed and why were they placed where we find them in the broad expanse of the continental plain? The answers to these and to many other questions are to be found chiefly in the geological history of the lake region and of the continent itself.

The accompanying map of North America, Fig. 1, shows that the Great Lakes lie in the east central part of the continent, where, excepting for the Adirondacks and the relatively low ranges of the Appalachian Mountains on the south, the whole vast area reaching from the Arctic Ocean to the Atlantic and the Gulf of Mexico is essentially a plain country that seldom rises more than one thousand feet above the sea. The region of the Great Lakes is a relatively quiet part of the continent; there is no evidence that it has had a turbulent history,

at least not since the beginning of the Paleozoic Era or time of ancient life, some 550 millions of years ago. The lake region, so far as known, has been visited by few earthquakes of importance, such as have been observed were relatively mild and rarely destructive. It has had no active volcanoes since the lake basins began to be made.

The Canadian Shield

The beginnings of the geological history of the Great Lakes are intimately bound up with the early development of the continent itself, and the continent has had a very complicated history, the early chapters of which are naturally more and more obscure as one goes farther back in time.

One of the most remarkable features of the North American continent is the so-called "Canadian Shield"—the great flat plain or low plateau which surrounds Hudson Bay, so named from a fancied resemblance to an inverted shield. It is for the most part a veritable rocky wilderness and extends a thousand miles to the east and to the northwest from the shores of the bay and more than half that distance toward the south and southwest. On a good geological map, especially if printed in colors, the shield stands out conspicuously, its gross area, including that of Hudson Bay and most of the Arctic Archipelago, amounting to something like one fourth of the whole continental surface. Two other shields of the same kind occur in high northern latitudes, the Baltic shield in northern Europe and the Angara shield in northern Asia, and it is a notable fact that they all have the same general characteristics.

The origin of the shields is one of the most obscure problems of geology, but whatever its origin, the Canadian shield stands in a peculiar and very significant relation to the Great Lakes. In Fig. 1, the southern boundary of the shield is shown as extending from the Strait of Belle Isle southwestward along the north side of the Gulf of St. Lawrence, up the St. Lawrence River to the vicinity of Montreal, thence westward along the north side of Georgian Bay and across Lake Superior to a point near the center of its north-west side. Here the boundary turns toward the northwest and passes through or near to Lake of the Woods, Lakes Winnipeg, Reindeer, Athabaska, Great Slave and Great Bear to a point on the shore of the Arctic Ocean about one hundred miles east of the mouth of Mackenzie River. Thus, on the southeast the boundary is marked by marine waters in the Gulf of St. Lawrence and on the south and west by a chain of lakes extending from Lake Ontario to the Arctic Ocean. In the north the boundary is not sharply marked, but in a rough way may be considered as passing northeast across the Arctic Archipelago and thence southeast to the Strait of Belle Isle. Some geologists include nearly the whole of Greenland in the Canadian shield, where, in all probability, it really belongs.

It seems certain that some sort of causal relationship exists between these features; but the complexities of ancient geological history have made it extremely obscure. It is worthy of note, however, that in Europe the southern boundary of the Baltic shield is marked in the same way by lakes and marine basins. Lakes Ladoga and Onega in Russia, with two or three basins in the White Sea and, on the west, the Gulf of Finland, the Gulf of Riga and probably a part of the Baltic Sea itself mark the boundary. In northern Asia, Lake Baikal may perhaps be related in this way to the Angara shield, but the relationship is not certain and no other lakes or marine basins so related are now known.

The surface of the Canadian shield is, in reality, a vast rock floor which, despite

FIG. 1. PART OF NORTH AMERICA

SHOWING THE LOCATION AND EXTENT OF THE CANADIAN SHIELD AND THE RELATION OF ITS BOUNDARY TO THE GREAT LAKES AND TO THE LAKES OF NORTHWESTERN CANADA. (AFTER SCHUCHERT.)

the vicissitudes of a varied history, appears to have kept its identity for hundreds of millions of years. But great as is the area of the shield floor now visible, this is by no means its whole extent, for there is evidence that it runs for undetermined distances toward the south and west under all the rocks of later age. In fact, it has been identified in deep borings at a number of places.

Alternative Views of the Probable Origin of the Lake Valleys

Studies of geological structure in the region of the Great Lakes made with special reference to their bearing on the way in which the lake valleys were shaped have resulted in a general agreement on certain points. First, the lake valleys were not made outright by a supposed gouging action of the ice in the ice sheets

of the Glacial or Pleistocene period, as has sometimes been suggested; nor, with the possible exception of a part of the basin of Lake Superior, are they to be considered as original rock-basins due to great hollows or troughs shaped directly by the folding and downward bending of the rocky strata; nor are they due to any form of marine action which would necessarily be limited to the work of waves and currents; but on the basis of many clearly defined evidences it seems certain that they are due almost entirely to subaerial erosion—to wind and rain and to rivers and smaller streams, like those we see to-day. But the magnitude of the lake valleys is so great that the idea that they were made by the agencies of ordinary subaerial erosion seems hard to believe, and becomes acceptable only when we give the streams an enormous allowance of time, at least tens of millions of years, for doing their work. But since the discovery of radio-activity in some of the most ancient rocks, a new and wonderful method of measuring geological time has been discovered and its adoption provides more liberally for the slow processes of nature.

The Building of the Paleozoic Sediments

In striving to visualize the main events which prepared the way for the making of the Great Lake valleys, it is to be remembered that, excepting probably part of Lake Superior, all the lake valleys have been carved out of the great mass of the Paleozoic rocks and that these rocks were evidently deposited in the ocean, for they contain the fossil remains of many kinds of marine animals. It is certain that the whole region where these rocks are now found was submerged under the sea for practically all the Paleozoic Era, estimated to have endured nearly 360 millions of years and ending about 190 millions of years ago.

But the attitude of the rocky strata has been greatly changed since that time, for from central New York to the south side of Lake Superior, the whole mass now dips moderately downward toward the south so that wherever their edges are exposed they are seen to project upward toward the north, as though they had formerly extended much farther in that direction. It seems certain that the Canadian shield or a considerable marginal part of it was submerged under the sea during all or nearly all of Paleozoic time; otherwise, it could not have received upon its surface so great a mass of marine sediments. The structure of the deposits shows that they came from a source toward the southeast or south and were spread toward the north over the nearer parts of the shield. Under these conditions, the slope of the beds as they were being deposited would naturally be toward the north, but would be very gentle for the finer sediments. Beginning at the bottom with very ancient sandstones and conglomerates (Cambrian), the Paleozoic deposits comprise, in their total depth, an enormous mass many thousands of feet thick, and including the sediments of all the six or seven periods which make up the Paleozoic Era, ending at the top with the coal-bearing beds of the Carboniferous and Permian periods. At places near the lake basins and especially near the southern boundary of the shield, the thickness of the deposits was less, because all the beds grew thinner toward the north. On the shield north of the lake region, their thickness was probably still further reduced. Then, too, practically all the coarser sediments had been deposited farther south and only the finer grades, like clay and silt, were carried for a notable distance out over the shield. Until the building of the Paleozoic rocks was finished, they appear to have rested quietly in the sea and to have suffered no

notable disturbance, at least in the area comprising the lakes.

The Erosion of the Great Lake Valleys

At length, toward the close of the Carboniferous period, a great change began, the exact nature of which is not surely known, but as a result the Paleozoic mass gradually became dry land. Two ways of explaining such a change have been considered by geologists: either the earth's crust was broadly uplifted over a wide area, thus raising the Paleozoic mass to a considerable height out of the sea and turning it into dry land, or, the solid earth remaining substantially undisturbed, the ocean waters gradually fell away to a low level, leaving the Paleozoic mass high and dry. Possibly both kinds of change were involved, but whatever its nature, the change probably came about slowly, not suddenly.

When the surface of the new land appeared above the sea, it was attacked immediately by all the forces of subaerial erosion—wind, rain, rivers and their smaller tributary streams and by the waves and currents of the sea along its shores. A drainage system with a central master stream flowing along the valley axis was soon developed on the site of each lake valley. In the valley of Lake Superior the master stream flowed toward the east; in Lake Michigan, toward the north; in Lakes Erie and Ontario, toward the northeast and east. In Lake Huron the course of the master stream was probably toward the north at first, but later may have been toward the south. A separate stream drained the valley of Georgian Bay, at first probably toward the north, but later toward the southeast. At first, all these streams probably flowed out onto the surface of the shield.

Early in their work the streams discovered the lines of the weaker rocks and in these they worked more rapidly. Thus, the weaker rocks determined the place and axial direction of the valleys and as erosion approached maturity, the influence of the softer rocks became more and more pronounced. At first, no outlets were found toward the west or south, but toward the east barriers of weak rocks separated one valley from another, as between Lakes Michigan and Huron, between Lakes Huron and Erie, and between Georgian Bay and Lake Ontario. With these barriers cut through, the main streams were united into a more compact system and were enabled to erode the valleys to their deepest parts. Because of the great duration of the period of erosion, the streams were enabled to widen their valleys extensively and by this means to bring them to their present shapes and arrangement.

The reason for the existence of Niagara Falls is the presence of the massive and relatively hard layer of the Lockport limestone or dolomite, with a great depth of soft rocks below it. More soft rocks, but not so thick, lie above it. The Lockport hard layer fades away eastward in New York, but it extends westward into Canada and, after turning around the west end of Lake Ontario, forms a bold escarpment extending northwest to the Saugeen peninsula, which separates Lake Huron from Georgian Bay. Beyond that it extends through Manitoulin, Cockburn and Drummond Islands, then through a range of hills a few miles north of the Straits of Mackinac and finally reappears in the Garden peninsula, Washington Island and the Door peninsula, which separates Green Bay from Lake Michigan. Thus, the valleys of Green Bay, the North Channel, Georgian Bay and Lake Ontario were excavated out of the soft rocks *below* the Lockport hard layer, while Lakes Michigan, Huron and Erie were excavated out of the soft rocks *above* that layer. Thus we see that after the greater things, like the existence of the continent itself and

the Paleozoic sediments, the most important factors in locating and shaping the valleys of the Great Lakes were the existence and arrangement of hard and soft rock-layers in the lake region and the peculiar selective action by which the forces of subaerial erosion made the valleys in the soft layers and left the hard layers almost untouched.

Turning the Dry Valleys into Lakes

The lake valleys were now completed, but there were no lakes; the valleys were still drained by the streams that made them. The transformation, however, was simple, for the Canadian shield, or a broad marginal part of it along the south and west sides, began to be slowly uplifted after the manner of a wide swell. This affected the land all along the boundary of the shield, the parts inside more than those outside, so as to produce a marked tilting downward away from the shield. Thus, the northern parts of all the valleys, with most of their outlets, were raised more than their southern parts, forming basins in which the waters gathered to form lakes.

The disturbances caused by the making of the Appalachian Mountains probably raised the Paleozoic sediments out of the sea and started the erosion of the lake valleys. This erosion, as we have seen, must have required a very long stretch of time, falling, perhaps, partly during the making of the Appalachians, but mainly during the long period of the Mesozoic Era or age of reptiles which followed. Certain it is that the whole of the lake region was continuously a land surface subject to subaerial erosion during the entire time of this era. The Mesozoic Era followed next after the Paleozoic, beginning about 190 millions of years ago and ending about 65 millions of years ago. It was, apparently, in the middle or latter part of the Mesozoic that the very slow tilting of the land in the lake region began to affect the newly finished lake valleys and turn them into lakes. Following the Mesozoic, came another era, the Cenozoic, time of modern life or age of mammals, comprising four or five Tertiary periods during which it seems certain that the tilting of the lake basins continued at the same slow rate. During all the Cenozoic also the lake region was a land surface and, excepting effects of erosion which are now largely buried under glacial drift, reveal no notable record of change.

The Pleistocene Ice Sheets and their Effects on the Great Lakes

With the opening of the Glacial or Pleistocene period, about one million years ago, came a new phase of the lake history. A series of continental ice sheets advanced from the north and northeast over the Great Lakes region, and while they did not make any of the lake valleys outright, they modified some of them considerably, but rather more by the deposition of drift in their basins than by glacial abrasion.

The cause of ice sheets is not definitely known, but many suggestions have been made. One that is now held in some favor finds the cause in a long-period variation in the quantity and intensity of solar radiation. At any rate, through several thousands of years the winter snows that fell on the higher ground surrounding Hudson Bay failed to melt in the following summers and, accumulating from year to year at a slowly increasing rate, finally produced a vast field of snow and ice—the beginning of an ice sheet. In forty or fifty thousand years, the ice on the Labrador peninsula, where it appeared to begin to grow, attained at its maximum a thickness of a mile or a mile and a half. The ice literally *flowed* away from the central area under the urge of its own gravity, but of course with extremely slow motion, much slower even than that of pitch or asphaltum in cold weather. It spread out over the whole of New England and the Great Lakes

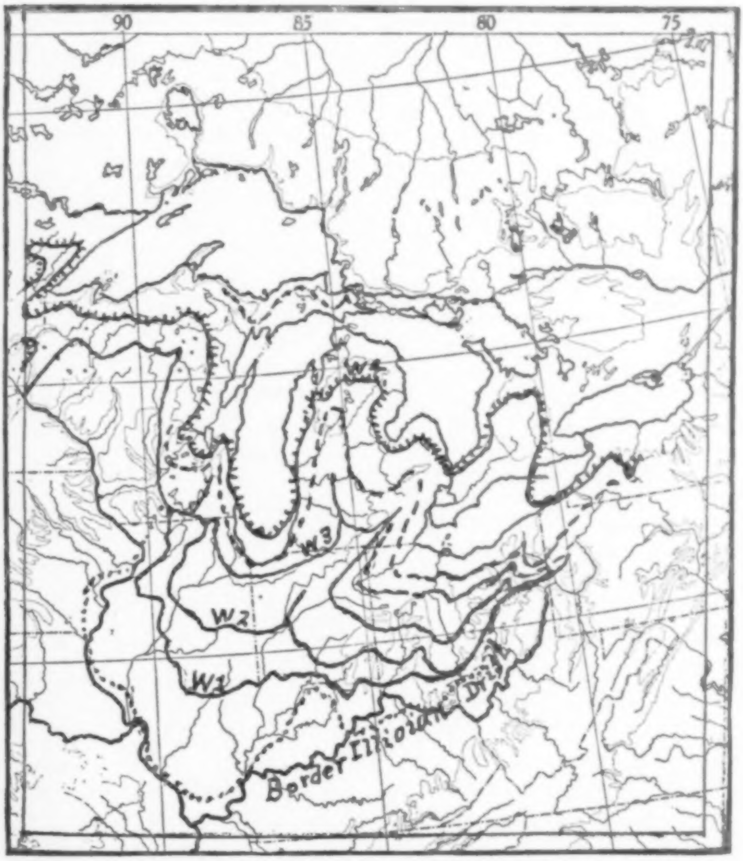


FIG. 2. REGION OF THE GREAT LAKES

SHOWING BOUNDARY OF THE ILLINOIAN DRIFT AND SEVERAL RECESSIONAL MORAINES OF THE WISCONSIN DRIFT. MORAINES MARKED W1, W2, ETC., WERE BUILT AFTER MORE IMPORTANT READVANCES THAN THE AVERAGE. TWO ADDITIONAL MORAINES INSERTED BETWEEN W3 AND W4 ARE SHOWN IN OHIO SOUTHWEST OF LAKE ERIE IN ORDER TO EMPHASIZE THE CLOSE RELATION OF THE ICE FRONT TO THE BASIN OF LAKE ERIE. ONLY A FEW OF THE RECESSIONAL MORAINES ARE SHOWN. (MAINLY AFTER LEVERETT.)

region. It moved over the tops of hills and even of mountains of notable height, but in order to do this by its own weight its surface had to have at least a gentle downward slope from its center of accumulation. Its semi-plastic movement enabled it to fit itself to the features of the land with perfect fidelity. Each lake valley became the site of a great lobe of the ice sheet and the high lands between the valleys became the heads of re-entrant angles giving to the front temporarily a scalloped pattern, like that shown in Fig. 2.

Four or five separate ice sheets swept over the lake region—the Jerseyan, Kansan, Illinoian, Iowan (?) and the Wisconsin. All covered nearly the same area, so that only relatively small parts of the earlier sheets have remained uncovered. Long warm periods intervened between the successive ice sheets; a wonderful record of one of them was found at Toronto showing leaves of warm-climate trees in

an interglacial bed. We learn how the ice sheets behaved in the lake region mainly from a study of the composition and distribution of the Wisconsin drift, because it covers practically the entire surface.

At its maximum, the front of the Wisconsin ice sheet rested on the Hartwell moraine ten miles north of Cincinnati. When the ice front began to retreat, it moved in an oscillating manner, as if by two steps backward, then a halt; one step forward, then a halt, and so on, oscillating all the way back to the northern highlands. The ice sheet built a marginal moraine at every halt, but all those built at backhalts were later overridden and destroyed by the next readvance, while all those built at forward halts remain as a beautiful record of the ice's oscillating retreat. These recessional moraines reveal intimately the relation of the ice sheet to the lake basins and to the land in general. From near Cincinnati to Lake Ontario there is a perfect series of twenty-seven of these moraines. Allowing a time for retreat, readvance and halt, which seems appropriate to the slow movements of ice sheets, it seems probable that each complete oscillation took one thousand to eleven hundred years, making the time of retreat to Lake Ontario nearly thirty thousand years. Then a few thousand more must be allowed for the retreat farther toward the north, so that forty to fifty thousand years would seem to be an approximate measure for the retreat from Cincinnati. How much more time has passed since then we do not know, except as Niagara Falls helps toward an estimate. It is believed that it has been eighteen to twenty thousand years since Niagara Falls began making the gorge at Lewiston. This seems a fair measure of the time taken for the ice to retreat from the south side of Lake Ontario to the northern highlands and probably includes also the time that has passed since the last of the ice sheet melted.

It seems certain that at the beginning of the Ice Age, the main rivers had cut deep channels between some of the lake basins. Borings indicate such a channel extending from Georgian Bay to Lake Ontario near Toronto. Another probably extends from Lake Huron to Lake Erie, and one may also have extended from Lake Superior to Lake Huron. No continuous deep channel is known extending from Lake Erie to Lake Ontario, but a boring at Euclid, a suburb of Cleveland, went nearly to sea level without meeting bedrock, showing that the rock basin of Lake Erie probably reaches sea level or lower, but owing to a heavy filling of drift, its greatest present depth is only a trifle more than two hundred feet. If the drift fillings were all removed some of the lakes would stand at much lower levels than now, and the lakes in general would present a very different appearance from those we see to-day. The valleys of the Great Lakes are very old; as water-filled basins, they are considerably younger; but as basins smoothed and slightly remodeled by the gentle touch of the ice sheets, they are relatively new.

THE SOUTHEASTERN CHINANTLA OF MEXICO

By Dr. J. STEWARD LINCOLN

A YEAR or two ago I fortunately had an opportunity to visit and make ethnological studies in the State of Oaxaca, a little-studied region of Mexico lying immediately west of the State of Vera Cruz.

The Chinantec villages visited were Lalana, Lachixola, Jocotepec, Rio Chiquito, San Jose Rio Manzo, Tepinapa, Toabela and Lovani, all situated in the State of Oaxaca, in a territory which stretches from the northeastern slopes of the Sierras to the borders of the State of Vera Cruz, an area of approximately 2,000 square miles shown in the accompanying sketch map (p. 58).

The Sierras cut off and isolate this tropical section of the Chinantla,[1] climatically designated as "*caliente humedo,*" from the Zapotec and Mixe regions, and communications over the mountains from the Southwest are through steep and difficult trails.

There appears to be a distinct Chinantec physical type as definite and outstanding as any in Oaxaca. The individuals of this type are medium in height, with black, straight hair, and pale, coffee-colored skin, with oblique slanting eyes and round heads, although there are numerous other physical types mixed up with the former. This difference in physical type may be caused by the custom, which is reputed to prevail, of inviting foreigners and visitors to have children by their women. If this is the true situation the stock can in no way be regarded as pure.

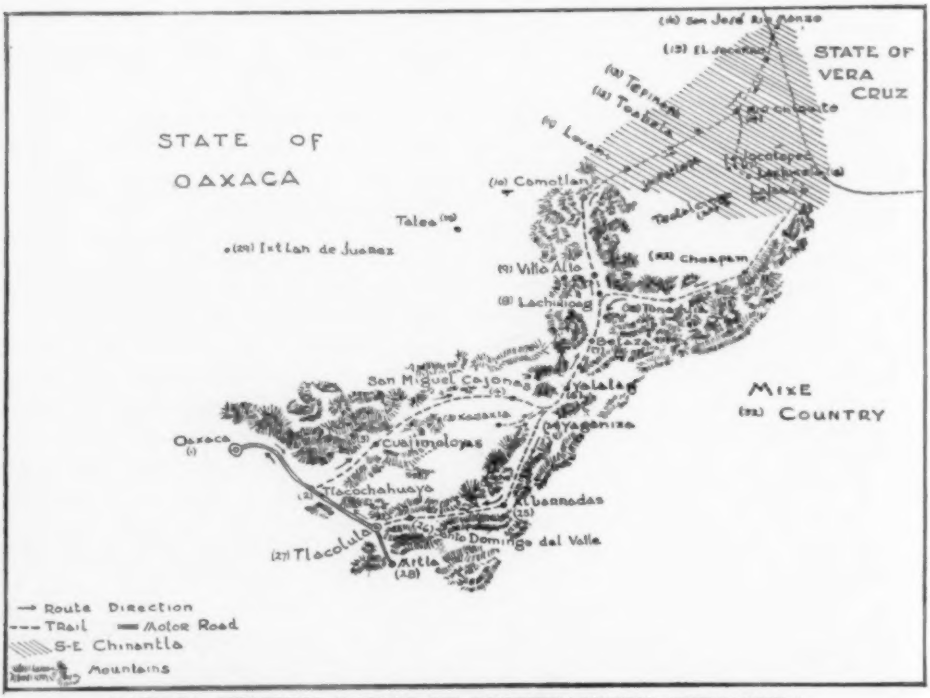
Throughout this section the women are good-looking, hard-working and prolific. They are shy, extremely reserved and inclined to hide and run away at the approach of visitors. The married women are distinguished from the unmarried by wearing their hair parted in the middle, twisted and coiled coronet fashion, with fan-shaped puffs over the ears. The unmarried girls keep theirs in braids, which are lengthened by twisting with strands of wool. When bathing, which always takes place in the open under a primitive shower bath, made by placing a bamboo trough in the steep part of a running stream, generally near the village, the married women sit down, but the unmarried girls stand. The married women wear a red cotton skirt, over which is worn a white *huipil*. The unmarried girls wear only the *huipil*.

Temperamentally, the people whom we encountered were gentle and reserved, but very soon become hospitable and generous hosts. Food was always forthcoming, and often no payment was requested in spite of evident poverty. This non-aggressive,[2] friendly and shy, temperament is quite in contrast to the unfriendly, sullen or aggressive attitude of the neighboring Zapotec men in the villages of Lachirioag, and Yalalag on the West of the Sierras, and the loud-mouthed, cackling and even brazen Zapotec women. The latter, however, have a keen sense of humor and are easily aroused to paroxysms of loud and side-splitting laughter.

In all the villages visited, both the men and women are hard-working, and have a well-organized, integrated town life.

[1] For description of fauna and flora, see Cayetano Esteva, "Nociones Elementales de Geografia Historica del Estado de Oaxaca," Oaxaca, 1913.

[2] It appears that in the first written historical record in which the Chinantecs were mentioned they were a war-like people and good fighters. Bernal Diaz del Castillo, "The Discovery and Conquest of Mexico." Broadway Travellers, 1933, pp. 373–74; 397.



OAXACA SHOWING RANGE OF SOUTHEASTERN CHINANTLA.

They are exclusively an agricultural people, and raise chiefly coffee, bananas, corn, sugar cane, tobacco and chiles. These products are raised almost entirely for home consumption, although a small amount of their excellent coffee is exported. One man in Jocotepec explained that he would like to export more coffee, but the difficulty of getting it to the railroad by human carrier made it too costly. Pigs, turkeys and chickens are raised. The men work in field and plantation, and the women do household work, cooking, drawing water and gathering wood, husking and grinding corn, making *tortillas* and looking after the family and domesticated animals.

Contrary to expectations, alcoholism seemed to be lacking as an every-day situation in all the eight Chinantec villages to which we traveled. No *fiestas* took place during a three weeks' visit; hence it was impossible to estimate the amount of drunkenness at these times. Probably it would have been most evident at *fiestas,* as in all parts of Mexico. Not one case of drunkenness was noticed, however, although one informant requested that he be paid in alcohol instead of money. The request was refused, but it did not make any difference in his disposition or his willingness to work. This situation is quite the opposite to that found in the high Yolox and Valle Nacional sections of the Chinantla where chronic drunkenness is the order of the day irrespective of *fiestas,* according to the report of a member of a scientific expedition to that region.[3]

The whole question of the effect of alcohol on the Indian organism and temperament is a field for the trained medical psychiatrist, and it would be worth while to pursue the study of alcoholism in relation to contact with advancing civilization. Whether chronic drunken-

[3] A member of Mr. Bernard Bevan's expedition.

ness among Mexican Indian groups is due entirely to inferiority feelings because of sudden contact with a new and crushing civilization, as suggested by Tannenbaum, is still open to question as a sole explanation. It would not explain why certain Zapotec and Mixe villages in the high Sierras, remote from the new order, are often encountered in which a state of chronic drunkenness exists, whereas the equally remote southeastern Chinantec villages do not suffer from this social disease. Constitutional, temperamental and social factors must here be considered in all their interrelations.

In the case of the southeastern Chinantecan villages, the remoteness is emphasized by the lack of roads, railroads or other modern means of communication with the outside world. The social plans of the revolution have barely begun to simmer through to these people. Of the eight villages visited, only two had schools and school masters. As a result there is a complete absence of medical or hygienic knowledge, and *curanderas*, who are often regarded as witches, are still consulted for cures of illness. Nevertheless, observation shows that personal cleanliness and numerous baths in the open are usual. Clothes, however, are apt to be shabby, ill-kempt or dirty, but the latter is partially compensated for by bodily cleanliness. In connection with personal hygiene, the Zapotec town of Yalalag presents a complete contrast from the villages of the southeastern Chinantla. Outwardly this town is clean and the two-story houses are newly painted in white. All the inhabitants are clothed in pure white cotton, the women in embroidered, hand-woven, clean-laundered *huipils*. Washing of clothes is constantly in evidence. On the other hand, the abounding filth and lack of sanitary arrangements make this town a peculiarly unhygienic one, especially called to attention in relation to the clean white clothes. The situation seems to be a combination of extreme cleanliness of clothes, with bodily uncleanliness.

Kinship terminology recorded in five villages now follows the Spanish family system, as in many parts of Mexico, with some terms expressed in Spanish, with no equivalent in native language.[4]

Lachixola (San Miguel)

It is interesting that a Chinantec calendar still in use should have been discovered in this village, which, from the reports of two informants, is probably not an ancient one.[5] The population now consists of about 70 individuals, which comprises 17 taxpayers and their families. About 30 years ago the population was almost wiped out by a smallpox epidemic. In a census of 1883 the population was given as 140; and in one of 1891, as 160.[6] There are two old men surviving the time of the epidemic, who still live in the village. During the epidemic, they remained outside of town on their *milpas*. The informants, Jose Arcienega and Francisco Feria, spoke practically no Spanish, and had as interpreter, the *Secretario*, Pedro Perez. Jose was a small child during the smallpox epidemic, and both his father and grandfather died then. The families of both informants have been in the village for several generations, exactly how long they did not know. They said that the tradition was that the village was founded as a *Rancho* by people from Teotalcingo, as a place to stop on the way from Monte Negro, a nearby trading center. A few stayed behind to plant and told others about it, and gradually developed the village of Lachixola. The date when this occurred is unknown. There is no memory of any important outstanding or

[4] J. S. Lincoln, "Zapotec, Chinantec and Mixe Kinship Terms in 1936." (Unpublished.)

[5] I. Weitlaner, "A Chinantec Calendar." *American Anthropologist*, Vol. 38, 1936, ap. June. Pp. 197–201.

[6] "Cuadros Sinopticos de Oaxaca," and an untitled census now in a church in Oaxaca.

venerated individual in the history of the town, according to Jose. There are two bronze bells hanging outside the church, one dated 1777, and the larger one dated 1740, with the inscription "Año Sphe." These were reputed to have been made in the village, possibly by a man from the city of Oaxaca.

Community and political organization follows a pattern found in small villages throughout Mexico. A town crier or *topil* calls for volunteers for public works, known as *tequio.* The latter may include building a hammock bridge or a new schoolhouse, or harvesting in the *milpas,* or whatever type of work is required for the community. The volunteers receive no pay. Lachixola has an *Agencia Municipal* under the *Municipio* of Lalana, a fairly large town about 15 miles away. There is one *Secretario,* one *Agente,* one *Regidor* and two *Topiles* (community errand boys). The first three act as judge, legislature and police, and have complete authority in the village. Any major crime is taken to Choapam, where there is a judge. Economic disputes and minor issues are taken to the *Alcaide* at Lalana. The judge in Choapam delegates his power to the *Presidente Municipal* in Lalana to marry people. Generally, people from Lachixola who want to get married must go to Lalana to the *Presidente.* Drunkenness is punished by putting the offender into the local jail in Lachixola. They are made to work under the authority of the *Agente* as a punishment.

Men leave town every day to work on their milpas,[7] or other fields. Coffee, maize, oranges and bananas are chiefly raised. Handicrafts are very weakly developed. They make coiled woven baskets and woven nets, but not as a business. There is no weaving of cloth and no pottery is made. Cotton cloth is imported from over the mountains, where it is woven by non-Chinantec people, and it is sewed together in the village for clothing. Houses are oblong, with roofs pointed and thatched with *rabo de bobo* and *zacate*[8] leaves; walls are of flattened, upright, thick boards and poles of *jonote* wood. The thatch and poles are bound with *bejuco* vines. There are doors to the entrances and openings for windows.

In Lachixola young people decide among themselves when they want to marry and when the decision is made, the man gets his father to ask the woman's family for permission to marry. The same custom also prevails in Lovani.[9] The groom's father must pay the bride's family from 12 to 15 pesos. If the young man goes to work in his wife's family, he does not have to pay. He pays only when she goes to live with his family. In Lovani, if the couple go to live with the groom's family, payment must be made to the father of the girl. In this village, if the groom or his family are unable to pay for the bride, the groom must work for a year in his father-in-law's house before he is free to return to live with his own family.

In Lachixola, the *Secretario* can sometimes get permission from the *Presidente* of Lalana to marry the young couple in the village. In some villages, a man can have two wives, but not here; and, of course, sometimes they marry into other villages. At the marriage there must be four official witnesses, two for the girl and two for the boy. The witnesses are given *aguardiente* to drink, but are not invited to the wedding party. The in-laws of the man go to fetch the bride, and all members of both families eat and feast together. In these days of few priests, whenever there is a *fiesta* in a nearby village, couples go there and get married by a priest. Lachixola is so poor that it can not afford a priest for its

[7] The word "milpa" is applied only to corn fields.

[8] Corn stalks.

[9] Informant—Don Remigio Martinez at Lovani.

fiesta of San Miguel on September 29. The girls do not wear the red skirt or *chiapaneco* until they are married. For the wedding, the bride wears a new *huipil*, slightly embroidered on the seams with colored thread. The groom gives the bride her clothes; and he wears a new white shirt and trousers. Boys and girls marry between 15 and 20. They marry "when they know how to work." In Lovani, girls marry between 13 and 16, and sometimes as early as 12. A girl of 18 in this village, who is not married, is regarded as having missed her chance. After the wedding ceremony in Lovani, the bride stays behind the door, while the groom goes all over town with the music and groups of men and women singing.

At the *fiesta* of San Miguel at Lachixola, there is no dancing. A band comes from Lalana and a *Maestro de Capilla* is sent for who knows how to intone prayers. There are no *puestas* or fair booths. Everybody wears clean clothes. Formerly they had the *chirimia* or flute playing for all ceremonial occasions, but they no longer have it. The player was changed every year, but now no one wants to learn to play. In the church, they have *rosario* service only when the *Maestro de Capilla* comes at the *fiesta* of San Miguel in September and for the *fiesta* of San Sebastian in January. This situation is different from the custom in Jocotepec, and other Chinantec and Zapotec villages, where *rosario* is held every morning before dawn without any priest. At the Mixe village of Tonaguia, *rosario* is also held every day before dawn. It seems that in the latter village, it is so long since a priest has been present they no longer remember the words of the responses. Attendants at the service intone responsively decidedly non-sacred phrases, many of which end with, "Viva Mexico!"

When people get ill in Lachixola, they buy medicine in the shop at Lalana. If seriously ill, they get a *curandera* from Jocotepec or one from Lalana. Recently the one from Jocotepec died. As mentioned before, there is no knowledge of hygiene in the southeastern Chinantla. At the birth of a child any woman may act as midwife. There were several cases of *pinto* in Tepinapa and in Lachixola, a disease whose chief symptom is the loss of pigmentation of the skin in patches which show on the hands, feet and face. Medical opinion regards this as a venereal disease, but differs as to whether it is contagious or not. It was noticeable that only one member of a family ever seemed to have this disease, in spite of living in crowded quarters, with wife, children and grandchildren.

In this same village, when a man dies, he is put in a sheet or straw *petate*, and he is buried in a cemetery outside of town. No money offerings are made. The house where the man died is left empty, with the door shut until the man is buried. After the burial, prayers are said for three nights for the family of the deceased in the house where he died. A wooden cross is placed on the grave.

In Lovani,[10] when a man dies, all his belongings are buried with him. Food, water and money are also buried to help him on his journey to the spirit world. The house where he died is often abandoned. Adults are buried with their heads to the west; and children with their heads to the east.

At San Jose Rio Manzo,[11] during a burial, the door of the house where the person died must be left open with somebody in the house, and a cross of lime is placed in front of the door inside. Prayers are held for nine nights. If the door of the house were not left open, all the people of the house would die.

[10] Informant—Don Remigio Martinez of Lovani.

[11] Informant—Magdalena Contreras, the *curandera*.

According to one informant, the customs at Lachixola have not changed. When there was a *Maestro de Capilla* settled in the village, they used to pray more, but he died in the smallpox epidemic. Nobody in the village has been vaccinated since the epidemic. The *Secretario* makes out death certificates.

They believe that dreams mean something is going to happen. If a person is going to hurt himself by a fall, or if he is going to be bitten by a snake, he will frequently dream about it first. I told Jose that I dreamed that an eagle flew out of an egg. He said that maybe the reason for my dream was because long, long ago, there used to be an eagle which carried people away.

A delightful tale was told by a young Spanish boy who had been brought up from childhood in the Chinantla and could speak Chinantec fluently. He accompanied the expedition for a week as interpreter.[12] The tale was told to his step-brother's father-in-law by a man from Playa Vicente, and goes as follows:

A man from Playa Vicente had lost everything in the revolution and was feeling very downcast, when his *compadre*, an old Chinantec, said to him, "I will cure your trouble." The *compadre* took him up the *Arroyo* Jocotepec, and said that he must not proceed any further, but the man was afraid to be left alone and insisted on going along too. They came to a place where there was a lot of *zacate* grass growing. They went through the *zacate* and came to the opening of a cave, which was hidden behind the tall growth. The old Chinantec would not let the other man enter, but went in himself and after some time, emerged with a very small *metate* made of pure gold, which he gave to his waiting friend. The old man forbade him ever to tell. The man from Playa Vicente took the golden *metate* and sold it for 250 *pesos*. The old Chinantec died, and the man who had been forbidden to tell of the secret cave, told the whole story to our interpreter's step-brother's father-in-law, who set out with the man to look for the cave. It rained and rained, however, so hard that they could not find the cave, and they both thought that the rain had been sent to keep them from finding it.

Later, an old Zapotec told our interpreter about the same cave in Arroyo Jocotepec. A young man had heard of it and went there through the *zacate*, tapping with his *machete* on the side of the mountain, and poking through the *zacate* until he had found a hollow place, which was the opening of the cave. He went in, and after he had gone in a long way, he came to a stream which he crossed, and a beautiful girl appeared, who said to him: "There is a lot of treasure in this cave and if you carry me across the stream and get me out of here, the treasure will be yours; only you must not be frightened if I change into a snake as you cross the stream."

The young man took her on his back and carried her and as they came to the middle of the stream, she changed into a snake. He became frightened and threw her into the stream. The snake went back to the side from which they had come and changed into a girl again. She said, "How foolish you are. If you had taken me to the other side, I would have become a girl again and the spell would have been broken, and you could have married me and had all the treasure."

The old Zapotec said that the same thing had happened to several other young men at one time or another, but to only one that he knew.

In Lachixola we found no witches or *Nahuales* and no witchcraft stories were forthcoming. The existence of such a thing was vigorously denied. A longer visit might, nevertheless, uncover such practices and beliefs as found in adjacent villages. In the town of Jocotepec, Lachixola was reputed to be teeming with witches, and in the latter they said that there were many witches in Jocotepec. In Lalana, however, the parent town of Lachixola, there was much talk of *Nahuales* and *brujeria*, and the following tales were collected. These are all cast in a rigorous pattern that is found in *nahual* and many *tona*, or animal double stories throughout Mexico, and in the literature.[13]

Nahual stories told at Lalana by Maria Sanchez, whose brother-in-law was reputed to be a *nahual*, June 3, 1936:

A man called Guadalupe Martinez found that one of his pigs had been killed by a tiger. He

[12] Juan Ramon Trinker.

[13] Bibliography of Nagualism in the Paul Vandervelde Library in Oaxaca.

knew that probably the tiger would return the next evening about the same time. He therefore decided to lie and wait for it, and he had his friend have a flashlight ready while he held the shotgun. When they heard a sound where the pigs were, the friend flashed a light and the tiger leaped over the wall of the pig pen. Guadalupe shot, but the tiger ran away. However the flashlight showed traces of blood so that he knew the tiger was hit. He set his dogs on the trail and he and his friend followed. The trail led to the house of Jose Cardozo who was generally suspected of being a *nahual*.

When they arrived at the latter's house, they saw the door of the house just being closed. They knocked and called, but it was a few minutes before they were admitted and they found Jose Cardozo in bed, apparently in great pain. They asked his wife what the matter was and she said he had been feeling badly since morning. Yet he died that night.

When Guadalupe shot the tiger, he saw that he wounded it in the shoulder, but it managed to jump the fence anyhow. At Jose Cardozo's house, they saw that he was clutching his shoulder under the covers, but his wife said he had a pain in his stomach.[14]

Two old women in Lalana, who were both *Nahuales*, had a violent quarrel, and after the quarrel, a fox would keep coming and killing the chickens of one of the old women. The fox did not eat the chickens, but merely killed them. The owner realized that the fox was the other woman, her enemy. She made a strong solution of hot chili pepper and lay in wait for the fox. That night, as the fox ran out of the chicken coop, she threw the solution in its eyes. From that day on, the other woman, her enemy, whose eyesight had been good, was blind and she never left her house again even to go to church. Formerly, she had gone to church every day.

There were two old men from near Lalana, who used to come to Villa Alta on Monday's market to sell salt. They had a quarrel. One of the old men became ill afterwards, and nobody could discover what the matter was. One of his friends noticed that every night a great bird like a turkey, used to come and perch on a branch of a tree near the house. By this time, the sick man was nearly dying. The friend shot the bird and by morning, the sick man was quite well. The bird was killed on Saturday night. On Monday the old man went to the market in Villa Alta. He saw that his enemy was not there. He asked where he was, and was told that he died Saturday night.

[14] "Tiger" is merely the literal translation of "*tigre*," the word used for the jaguar, which roams that country.

Doña Maria's father had a quarrel with his son, who became very angry with his father and said to him, "You will wake up dead. (*Amanecerás muerto.*) I am a *nahual.*" The father turned and hit him in the face and broke his nose, so that the blood came. Doña Maria commented that if a *nahual* makes a threat, he can be rendered powerless to do harm if the threatened person hits him in the face until the blood comes.

She also said that Jose Anacleto, who lives on his *rancho* near Lalana, is the only living *nahual* left, but she went on to add that *nahuales* get their power to change into animals from the smooth stone on the Cerro de Ocote just off the road to Playa Vicente, about half a day's journey from Lalana. A power is received by praying to the stone. She told us that the *nahuales* from Latani stole the stone from the *nahuales* of Tepinapa.

From another source,[15] it was affirmed that a village called Rio Tinto, near Tepinapa, was destroyed by the *nahuales* from Tepinapa, and the remaining families founded the village of Lachixila.

The Chinantec guide, who conducted us from Lalana to Choapam, said he had once shot an animal who was a *nahual*. He said that in order for a *nahual* to change into an animal he must go to a special place in the woods, where prayers and offerings are made. He must take off his clothes and roll naked down the hill, and as he rolls, he turns into a *tigre*, or a fox, or some sort of an animal.

A first-hand account of how a man became a *nahual* without realizing for some time that he was one was given to me at San Jose Rio Manzo by his wife, Magdalena Contreras, a much sought-after and well-known *curandera* in this district. The story is of special interest

[15] From Jose Cruz, now of Montenegro, formerly of Lachixola.

because it shows that a definite involuntary, psychological state may exist in an individual, which causes him to regard himself as a witch. If it is possible to accept his wife's statement as evidence,[16] this report is the record of a psychological case,[17] which means that it is in a category quite distinct from mere folklore or a traditional tale. Sufficient items of the life history of the individual are given as associations, thus making it possible to understand this case as one of dissociation of strong murderous and aggressive impulses, in spite of fantasy elaborations of his wife.[18]

Told to Miss Natalie Scott and myself on May 27, 1936:

My husband, who was from Lalana, was the eldest of a large family. His mother and father were normal people. He was given to fits of violent temper from childhood on. I married when I was 16 and then went to live on a little cotton plantation below El Socorro on the Rio Manzo. He was a good worker and kindly, except when he had his fits of temper, which would come on as sudden as thunder. When drunk, he was always violent and cruel. In a fit of temper or when drunk, he would beat me with a stick or cut me with a *machete*.

After we had been married about 12 years, he began telling about the dreams he had. He used to dream that he was ranging the mountains, doing harm and killing lots of animals. He would dream that he went to a place where there were lots of turkeys which flew away in great fright. He would dream that he found himself in a place where there were dead sheep, calves or pigs, and he would know that he had killed them. He would also dream that he was chasing animals to kill them.

He asked me why he was dreaming such things and I said it was just foolishness. The dreams continued for three or four years, and worried him. He never thought he was a *nahual*.

One day he went to Playa Vicente on an errand. When he reached the beach, he suddenly felt very sleepy and lay down and slept and dreamed that he was shot through the abdomen. When he awoke, he felt so ill he started home at once. About an hour out at Boca de Savana, he saw the head of a *tigre*, which had been burned. The people there told him that this *tigre* had been doing so much damage to the animals that a large group had gone out to hunt it. They had shot it, skinned it, salted the skin, and burned the body.

When he reached home, he felt very ill and blisters appeared on his hands and mouth and he didn't want to eat, but was very thirsty and he drank many jars of water because of the salt they had put on the *tigre*. He realized then that the tigre was his *nahual*.

Four days after his dream and after having seen the head of the *tigre*, he died. During this time, he complained of the pain in his abdomen, although there was no sign of injury there. The night he died, there was a full moon. I was alone in the house with him, while the two children slept, with all the doors closed. I heard something outside and my first thought was that it was a pig, but then I realized we had no pigs, I went to the door and opened it just a crack and clearly saw a *tigre* in the moonlight, snuffing at the house. The *tigre* kept circling the house and snuffing and even scratching at the house. Just before my husband died, the *tigre* roared several times. I spoke to him about it and said, "Don't do me any harm, even if you are a *nahual*," and he said, "Don't be worried; it won't hurt you." After that, he died.

On the skin of the left shoulder of the *tigre* that had been killed, were seen the letters of my husband's name.

In a previous work, I have given instances among the North American Indians of witchcraft, as well as many other aspects of culture arising from dreams.[19] The above case is an example of a person realizing that he is a witch from his

[16] Maria Contreras' husband had died four or five years before according to the statements of other individuals in her village, and at El Socorro nearby he was regarded when alive as a *nahual*, and was known to be a man of violent tempers.

[17] In France cases of individuals who regarded themselves as werewolves and believed that they changed into wolves and roamed the country killing animals and children are recorded in the past. Cases tried at Angiers in 1598, and at Bordeaux in 1603 occurred in both of which the accused were convicted of being werewolves, but were treated as insane. (*Encycl. Brit.* "Lycanthropy.")

[18] Maria Contreras spoke no Spanish but Juan Ramon Trinker, who spoke fluent Chinantec, acted as interpreter.

[19] J. S. Lincoln, "The Dream in Primitive Cultures," p. 75. The Williams and Wilkins Co., Baltimore, and The Cresset Press, London.

dreams. The content of the dreams, together with the items of life history, clearly show that violent murderous wishes and aggressive impulses, which are largely repressed, dissociated and projected onto external events are some of the psychological factors at the basis of nagualism as an actual practice. Proof of this is given by the fact that he identifies with the murderous *tigre* who was shot for doing harm to the neighborhood. There are obviously many more factors to nagualism both psychological and historical than mentioned here. The above is merely a superficial analysis obvious to any psychologist.

In conclusion, the traits that can be singled out to differentiate the southeastern Chinantla culturally from other sections are, the monosyllabic isolating Chinantec language with its many difficult tonal changes (with two dialects in the northern and southern sections);[20] the almost complete absence of handicrafts such as weaving and pottery making, although the people are close neighbors to the Zapotec experts in both these crafts; and the concentration of witchcraft belief, folklore, and practice. Witchcraft patterns are found throughout Mexico but appear especially concentrated in this region, and offer a most fruitful field of research for the psychologically trained ethnologist. The report of the Pan-American Union of Mexico City now in process of being made is sure to present a more comprehensive study of this interesting and unspoiled area.[21]

EXTRACTS FROM TWO UNPUBLISHED LETTERS OF LINNAEUS

By Dr. W. M. SMALLWOOD
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DURING the summer of 1937, Mrs. Smallwood and I were examining the letters and lectures of eighteenth-century professors at the University of Edinburgh in an effort to discover what the American boys who had studied at that great institution were taught in the realm of natural history. Among these manuscripts we came upon several letters exchanged between Linnaeus and Walker, which we found very interesting, and from which I am here including brief extracts. For permission to copy and publish these Linnaeus-Walker letters, I wish to thank F. C. Nicholson, Esq., librarian at the University of Edinburgh.

The possible distribution of one of the Alpine heaths in Scotland or Ireland—the mistaken interpretation of the capsule of the moss—the study of zoophytes as plants—these are among the natural history problems discussed by Linnaeus and Walker.

> Si vous faites moi la faveur de Response diriger, S'il vous plait, par la route de la Poste,
> M. John Walker Ministre de l'Eglise, de Glencorse, a Edinbourg, en Ecosse. [Scotland].

Thus ran the close of the Reverend John Walker's first letter to "My Dear Sir, Linnaeus, Knight of the Pole Star, Physician in service of the King of Sweden, and Professor of Botany at

[20] Jaime de Angulo, "The Zapotecan Linguistic Group." *International Jour. American Linguistics*, 8: 1, December, 1933.

[21] I wish to express my thanks to Miss Natalie Scott, of New Orleans, whose thorough knowledge of Spanish and trained experience in the by-ways of Mexico were invaluable to my wife and myself, and to Don Manuel Gracida, of Oaxaca, who so conscientiously and expertly guided us and our horses through the difficult and sometimes dangerous mountain trails.

Upsala, Sweden," written on January the eighth, 1762. The reading of these letters takes us back to that interesting period when men were beginning to bring a little more order into their observations; and their phraseology reveals a generosity and friendship in which we of to-day are too busy or too thoughtless to participate. I am grateful to Dr. L. W. Sharp, of the library of the University of Edinburgh, who carefully checked the copies of these letters with the Latin originals. I am also indebted to Professor Perley Oakland Place, of Syracuse University, for their translation. Their Latin, according to Professor Place, reveals numerous echoes of Cicero's style combined with colloquial freedom in the use of cases. Although the letters were written in Latin, the complimentary endings were in French.

The four letters which were exchanged between these two men over a brief period of eighteen months throw much light on the interest taken in botany and zoology by the amateur preacher-naturalist, who was, in 1779, to become a professor of natural history at the University of Edinburgh, and the already-famous Swedish scientist.

When Linnaeus received John Walker's first letter, he was busy with a revision of his "Systema Naturae," which is popularly known as "the thirteenth edition." He had recently been presented with a gift from the King of Sweden and had been permitted to name the successor to his chair at the University of Upsala. The time had come when Linnaeus was feeling the burden of his teaching duties, and he had written to Chancellor Höpken, at the university, that, "as he had regarded science more than his life, he had worn out his body, shortened his days, and brought on too soon the infirmity of old age."[1]

Walker clearly recognized the greatness of the man to whom he was writing; for, in his first letter he said:

> In the field of Botany (*In re herbaria*) you have seized, in advance of all, the palm of victory, so that you have ascended a pinnacle to which the discouraged hearts of others never attain. Your own genius has opened this path of glory, it has carried the torch, it has lifted the signal, it has laid firm foundations for your honors.

The English Church at Glencorse was some twelve miles south of the city of Edinburgh, but this did not deter the young pastor, The Reverend Walker, from taking an active part in the intellectual doings in the city. There was the university with its famous medical school; and several societies whose members were drawn both from the university and from those residents of the city and of nearby towns who were especially interested in natural history.

These letters were partly concerned with an invitation to Linnaeus to become an honorary member of the Philosophical Society, organized in Edinburgh in 1739. Walker was very frank in telling Linnaeus about the manner in which the activities of the society had declined, and the eagerness of some of its members to revive them:

> The Society that was established in Edinburgh to promote philosophical studies, although it has faded for a long time, is, nevertheless, I hope, to bloom again; and in the future (the members) will employ greater diligence, in order that Natural Science may gain increase; and their own work will be brought more often into the light of day. I desire to know whether the volumes which this Society has made available to the public have come into your hands, or, if you have been without the opportunity of reading them, by what route they can be brought to Upsala. Furthermore, I ask you to inform me whether you wish ours to be the one of the Societies with which Linnaeus deigns to associate himself. . . .
>
> Because of my regard for Botany I can scarcely endure with a calm spirit its present neglect. I have desired to put an end to this neglect, and I have determined to ascertain whether it is possible. Impelled by this purpose, I seem to feel that the best plan is to present this science briefly and to make it easier at the

[1] "Linnaeus," B. Daydon Jackson (London, 1923), 324.

beginning, in order that by this plan the hearts of the young may burn with desire to learn Botany. And, furthermore, nothing could better contribute toward the attainment of this end than catalogues carefully compiled of foreign and native plants. This is apparent from the general agreement of Botanists, since by far the most numerous classes of Botanists are the "Adonistae" and "Floristae."

The lack of activity, or "present neglect," of which Walker complained, was probably due to the Scottish uprising in 1745 which aimed to place Charles, the Stuart Pretender, on the English throne. In 1752 the society's meetings were resumed; and in 1782 the "Philosophical Society" was rechartered as the "Royal Philosophical Society of Edinburgh."

Charles Alston's long teaching career was drawing to a close. He had been trained at Leyden under Boerhaave, and was the last of the apothecary teachers. He was an intense opponent of the new Linnaean system; and his final scholastic effort, after he had retired, was to publish a paper which he hoped would definitely refute the pernicious sexual system: "A Dissertation on Sexes in Plants."[2] But this last of the Edinburgh herbalists, or "Adonide," was to be disappointed; for the Reverend John Walker, seeking the favor and help of the man whom Alston had opposed, was laying the foundation for a different method of teaching, of which he was to be the first exponent at Edinburgh.

At the time these letters were written, teaching at Edinburgh was of a practical nature and centered in herbal gardens, fundamentally established for apothecaries and medical students. The maintenance of these gardens was so great as to make them impractical for general study. Walker wrote that "a different way" must be found "according to which the hearts of the young may be inspired by this study." He lamented that the Scottish youth had neither a list of their local plants, nor was there a local herbal: ". . . we are equally destitute of Floras and Adonides [*sic*]. Nothing of this kind is superior to the Compendium of Rajus," he said, but it, the *Compendium*, is not at all "suitable for Scotland, since the testimony of the authors relates only to regions of England."

Apparently Walker had made up his mind to "break" with the local teacher of botany, Alston, for he wrote: "And since I have decided to follow the sex-system, I thought that it was best to consult the author of it." This long letter concluded with a description of the common moss, *Bryum striatum*.

To this first letter Linnaeus replied as follows:

Charles Linnaeus, Knight, sends greeting to John Walker, a most distinguished gentleman.

For a long time now I have been grieved because, after my good friend I'sac Lawson died, I have not found in all Scotland a friend with whom I could discuss the plants of that region, and by whom I could be instructed in them. And so with happy omen you, honored Sir, have come into my path. Therefore, for both reasons, I eagerly receive your great service to me, and I acknowledge it with gratitude.

There can be no doubt that Scotland will be found to rejoice in a great many very rare plants, not in the list of Rajus, nor in other accessible works, since your region abounds in very high Alpine mountains, forests, and waters. For many years I have left no stone unturned, that I might obtain one perfect specimen of the Erica Daboecii.[3] . . . Nor have I been able to obtain it; it is, to be sure, a plant of Ireland, and is not a native of Scotland; but I do not doubt that it is even found in your Alpine mountains. . . .

I have read the Edinburgh Proceedings, [*Proceedings*, Philosophical Society of Edinburgh], which are for physicians the most excellent proceedings of all the learned Societies. In them I have found but few things pertaining to

[2] Charles Alston, "A Dissertation on Sexes in Plants," from *Physical and Literary Essays*, I, second edition (1771).

[3] Through the courtesy of H. D. House, Esq., New York State botanist at Albany, we learn that: "*Erica Daboecii* (Linn. Sp. Pl. ed. 2, p. 509) is now designated as *Daboecia polifolia* Don (Ericaceae), and related to Erica. Distributed from northern Spain and adjacent France to Ireland."

Botany, except the species of *Caldenii*[4] and *Hyperici*.[5]

You ask whether I should wish to be received into this famous Society; I do not see how it could be done, as long as Cl——— is a member, [*atro carbone*] who has put such a black mark against my name.

It has been difficult to interpret the meaning of Linnaeus' expression, "atro carbone." Our first thought was that "black-balled" was indicated; but Mr. Nicholson, librarian of the University of Edinburgh, doubted there having been any such action as "black-balling" implies. We then sent a copy of the complete paragraph to Dr. M. L. Green, at the Royal Botanic Gardens in London. She, in turn, submitted the problem to Mr. Savage, of the Linnaean Society—and three possible translations were thus suggested, from which we have selected the most literal.[6] We have also considered whether the "Cl——" might not be "Al——," meaning Alston; but there seems to be no doubt but that Linnaeus wrote "Cl——," and we are unable even to guess as to whom he refers.

Walker attempted to fit his observations on the moss, *Bryum striatum*, into the taxonomic pattern used for flowering plants as male and female flowers.[7] This mistaken observation excited Linnaeus and he wrote:

With amazement I read your description of the *Bryum Striatum*, and with great impatience I am awaiting the first days of spring, when I can search for the male flowers of this *Bryum*, which you first discovered and thus anticipated me; surely if I shall find in it the eight named *stamina*, that moss, with your observation, will unlock a new chamber of Nature, through which we shall enter a hitherto hidden palace of Nature; nor will there be a doubt that we shall have similar success in the other mosses. If this should happen, as I ought not to doubt your eyes, surely it would bring to you immortal fame. As a result of this one experiment I do not doubt that you are one of the keenest Botanists.[8]

Continue, as you have begun, and enter the hidden places of Nature, and conquer new kingdoms there; and, furthermore, keep in your heart your love for me.

Upsala, February 22, 1762.

If you write in reply, address your letter to The Royal Society of Sciences of Upsala; I open all its letters.

Walker was successful in his request

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[4] Mr. House also tells me that: "It is extremely likely that the name '*Caldenii*' refers to *Coldenia*, a Linnaean genus of the Boraginaceae. There is no botanical generic name Caldenia (or -ium)."

[5] According to Mr. House, *Hyperici* would naturally, as I had suggested, refer to *Hypericum*.

[6] Dr. M. L. Green suggested in a letter to the writer: "Therefore I think it is better to translate the passage in one of the following ways: 'I do not see how it could be done as long as Cl—— is a member who has attacked me so virulently,' *or* '. . . who has disapproved of me so strongly,' *or* '. . . who has put such a black mark against my name.' "

[7] With Walker's first letter to Linnaeus, he enclosed the following, together with drawings of plants:

Character of *Bryum striatum* (Sp. Pl. p. 1115, n. 2).

Male flower

terminal, solitary, sessile.

Filaments	eight, compressed, connivent, of which the four in the middle are shorter.
Anthers	eight, blackish purple, sub-rotund, incumbent, sprinkled with purple powder.
Receptacle	foliaceous.

Female flower

terminal, solitary, on a different plant.

Peduncle	very short, filiform.
Calyx	calyptra conical, striate and pale.
Pistil	ovary ovate. . . . Opercular style deciduous, spherical at base, filiform toward the apex. . . . Stigma acute.
Pericarp	Capsule ovate, unilocular, the mouth with slender teeth.
Seed	powder-like.
Receptacle	foliaceous.

[8] Dr. M. L. Green, in a letter to the writer, said: "The scientific problem involved in the life cycle of mosses was fully cleared up in Hofmeister's 'Vergleichende Untersuchengen,' published in 1851. An English translation, produced by the Ray Society in 1862 under the title of the 'Higher Cryptogamia,' included also his cognate researches on the Coniferae. This great synthesis, which brought alternation to the front, has proved itself to be the foundation for all subsequent morphology of land-living plants."

that Linnaeus be made a member of the Philosophical Society, as shown in his second letter, dated October 12, 1762.

I have received your letter written at Upsala, a most welcome letter, since I learned from it that you are well. With very great pleasure I welcome this opportunity to inform you, at the request of the Edinburgh Society, that on June 17 you were unanimously elected to membership. On the same day John, Count de Bute, and his brother, Mr. Steuart McKenzie, natives and ornaments of Scotland; one, to-day governor of the whole British Empire; the other, envoy to the king of Sardinia; these were received into this Society.

I have explored the Scotch mountains this summer in quest of *Erica Hibernica*,[9] but thus far to no purpose. Ireland at this time provides no one experienced in the field of Botany. I have written to the Bishop of Ossory (Mr. Pococke, Asiatic traveller), and to a physician in the town of Dublin; and, if the matter turns out well, you will hear later.

To return to the first letter, referring to his proposed list of plants, Walker said:

To this *Flora* I have decided to add a catalogue of the Submarine Zoophytes, of which very many are found on the nearest shores. Accordingly, I have chosen this opportunity of leading those who are interested in the science of Botany to a knowledge of these sea-offsprings; not a few have the opportunity in warmer regions to examine the Zoophytes while these are still alive. In the history of these, much is lacking; since thus far they have been examined in carefully preserved specimens. Although animal life plays the principal part in these mixed bodies, nevertheless, when they are arranged in order, they should, I think, be considered plants rather than animals, because their species can best be investigated from their ramification and external appearance, rather than from the microscopic living things that constitute them and dwell in them.

To which Linnaeus replied: "I do not doubt that you can wonderfully enlarge the history of Molluscs, Zoophytes, Lythophytes,[10] even now incomplete. I wish that you would undertake this."

Linnaeus, at this same time, was carrying on an active correspondence with John Ellis, who was the foremost student of corals, and was maintaining in a letter to Ellis, dated September 16, 1761, that:

Zoophyta are constructed very differently, living by a mere vegetable life, and are increased every year under their bark, like trees, as appears from the annual rings in a section of the trunk of a *Gorgonia*. They are therefore vegetables, with flowers like small animals, which you have most beautifully delineated. All submarine plants are nourished by pores, not by roots, as we learn from *Fuci*. As Zoophytes are, many of them, covered with a stony coat, the Creator has been pleased that they should receive nourishment by their naked flowers. He has therefore furnished each with a pore, which we call a mouth. All living beings enjoy some motion.

The Zoophytes mostly live in the perfectly undisturbed abyss of the ocean. They cannot therefore partake of that motion, which trees and herbs receive from the agitation of the air. Hence the Creator has granted them a nervous system, that they may spontaneously move at pleasure.[11]

Corals were classed as Lythophytes, and sponges and Hydroids made up the Zoophytes. It was more than fifty years after the dates of these letters that these terms were finally given up. The name "Porifera" was adopted in 1835, and "Coelenterata," in 1848.

As we read further in these letters, we see that rare plants and Zoophytes were but phases of the interests of Linnaeus. Mr. Alexander Dick's practical manufacture of paper from plants—his own correct information about the metamorphosis of the May-flies—his credulity in partially accepting Walker's description

[9] On consulting Mr. House, I learned that: "*Erica hibernica* Syme (and apparently Linnaeus did not coin this name) is a synonym (fide Index Kewensis) of *Erica mediterranea* Linn. Distributed from Ireland through southern Europe."

[10] "Zoophyte" is an old term, having been used by Aristotle. It was more than 2,100 years later that these "animal-plants" were correctly interpreted. "Lithotype" was used by Sir T. Browne, in 1646: "That Corall (which is a Lithophyton or stone plant." Lyell, in 1875 retained this term. It was used much later for lichens and mosses by Kerner and Oliver.

[11] *Correspondence of Linnaeus*, compiled by James Edward Smith (London, 1821), I, 151.

of the moss flowers—all reveal the character and scope of the famous Swedish naturalist's mind.

Walker wrote:

Recently I have observed *Ephemera* to shed its skin entirely, and that instar to shed a skin while in the winged stage of its life. I do not know whether this metamorphosis has been observed by others; I have noticed it in all the specimens of Ephemera. . . .

In this packet of letters you will find specimens of paper, and of the plant from which it is made. A large supply of this paper was made in the beginning of the present year by the noble Sir, my most upright friend, Mr. Alexander Dick, Golden Knight, most worthy President of the Royal Edinburgh College of Physicians. This aquatic plant grows in very great abundance in ponds at his villa near Edinburgh, and I wish you to inform me whether it is *Confera Bullosa*, *Syst. Nat.*, p. 1346, n. 3. He asked me to send to you, with his best wishes, these specimens, along with the paper, named *Linnaea* after his daughter.

Linnaeus, in his second letter, first acknowledged the honor of his election to the Philosophical Society, then commented on the specimen of paper, which Walker had sent to him:

A most friendly letter, written by you last year, in fact, on October 12, I received fourteen days ago; I do not know where it has remained unnoticed so long. With deepest gratitude I acknowledge the esteem with which the illustrious members of the renowned Society of Edinburgh have received me, when they wished to adopt me as a member of their Society. Would that I could return their kindness in a manner worthy of them! You recommended me, I hope without detriment to your reputation.

I am sorry that *Erica Hibernica* has withdrawn from its fellow-countrymen. But, if Alpine, I know by experience how difficult it is to find Alpine plants. I am astonished at his skill in making paper from a water-plant; certainly it is a beautiful success; I think that it must be the *Confera Bullata*, everywhere of most frequent occurrence; surely it can be prepared from other water-plants. I certainly wonder that Mr. Alexander Dick could have foretold this. Please greet the noble maid who has inscribed this paper with my name.

In regard to the metamorphosis of the *Ephemerae*, the fact is very well known among Zoologists. The specimens of *Bryum Striatum* were beautiful, but even now I doubt whether they are true stamens, or another off-shoot; surely in most mosses the *anthera* is concealed in the cover (*operculum*) itself, as I have shown in my dissertation on the *Buxbaumia*. I wish that you would undertake the task of proving this, and that you would consult many: you can best do this; I can not, as I am not in the city. . . .

These brief extracts from the correspondence of the two naturalists, one the great Linnaeus, give an intimate and accurate picture of the activities of the two men, and carry within themselves their own interest. The letters are long; but the extracts which I have made include all the matter of any considerable scientific importance. According to Dr. L. W. Sharp, who has charge of the department of manuscripts in the library of the University of Edinburgh, these Linnean-Walker letters have not heretofore been published.

THE EXACT SCIENCES IN A LIBERAL EDUCATION

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BEFORE attempting to discuss the place of the exact sciences in a liberal college curriculum I should like to briefly define what is meant by this title. The exact sciences are physics and chemistry, though mathematics, considered as a body of knowledge based upon experience, is included as well. Physics, with its contacts with mathematics on the one hand and chemistry on the other, and its vast fields of practical application, is the most representative division of the exact sciences and provides the best illustrations of the scientific method. The word liberal, however, is more difficult to define. It has seven or eight specific meanings for the lexicographer, and any one who has followed the recent correspondence in the magazine *Time* regarding the liberalism of President Roosevelt realizes that it has as many popular meanings as there are interpreters. My understanding of the word as applied to education is merely the differentiation of the general term from technical and professional instruction. The rôle of the sciences in the professional fields is so obvious as to need no discussion, but there is often a tendency to consider that science is only the concern of the technician and that it is for him merely a tool to be used during the forty hours per week in which a benevolent government permits him to work. This is much too narrow a view, for the exact sciences occupy the most important position in any modern curriculum designed to produce a liberal education.

I should, perhaps, exclude the case in which liberality has been carried so far as to have become a travesty on education. If the educator is so liberal that the educatee is free and untrammelled to wander at will through the academic grove, choosing what fruits please his immature fancy to the great detriment of his intellectual digestion, there is no need for the educator and little occasion to have any of the fruits of the exact sciences available. These fruits would not mature in such an uncongenial atmosphere, and should they perchance be selected, there is little likelihood of their being digested. The extreme example of this is a program made up of elective survey courses. Such a curriculum overlooks the fact that it is necessary to know at least one thing well and establish a firm basis of competence over some small body of knowledge before proceeding to a broader understanding of other fields. To reverse this order at the approach of intellectual maturity is the underlying cause of intellectual slovenliness and superficiality. Such complete liberty of choice, based on the idea that the student knows what is best for him and that he is always right, amounts to license, and a faculty is greatly at fault if it does not chart certain general paths or sub-curricula to be followed by different students according to their bents, in order that they may acquire a conception of the organization of a field of knowledge.

The question as to what the well-educated man should know is too broad to be answered except in the most general terms. He must, of course, be able to read and speak and write his own language. To make the last two accomplishments of any value to others than him-

self, he must be able to carry out certain simple logical thought processes. To this minimum should be added as wide an acquaintance with his cultural background and surroundings as he can obtain; this involves some familiarity with other languages, history and the arts. Finally the process of education is incomplete if the seeds are not sown that will result in the student himself making some contribution to the diffusion, application or enlargement of knowledge for his own sake and that of his fellows. The rôle of exact science in education will be considered in terms of these three categories: as a training in exact thought, as the basis of our modern culture and as the main stem of our intellectual growth.

Consider first the development of logical habits of thought. The nature of science and the discipline it imposes provides the best possible training in accurate reasoning. Just as the trivium of grammar, rhetoric and logic provided the mental discipline of the medieval schools, this same discipline is provided to-day even more strictly by mathematics and the sciences. The necessity for ordered and accurate mental processes is not realized by the intellectually immature any more than a child understands why jam is an unsatisfactory diet. But it is the chief duty of the instructor to point this out by precept and example; to "Learn, never grudge the pang; strive, never grudge the throe." Good mental habits can not be instilled painlessly, but the net return to any man on a mental investment is directly proportional to the effort and assiduity he himself has expended. As in starting a savings account, the first deposits are not easy to make. Study is not a heroic emotional action, but is undertaken only upon good advice and guidance. Nothing could be more valuable than a good set of skeptical, analytical and logical mental habits once they are acquired. As William James writes: "As we become permanent drunkards by so many separate drinks, so we become saints in the moral and authorities and experts in the practical and scientific spheres by so many separate acts and hours of work. Let no youth have any anxiety about the upshot of his education, whatever the line of it may be. If he keep faithfully busy each hour of the working day he may safely leave the final result to itself. He can, with perfect certainty, count on waking up some fine morning to find himself one of the competent ones of his generation." Beware what you set your heart upon, for it shall surely be yours. The intellectual maturity represented by a disciplined mind is a thing greatly to be desired.

Accurate habits of thought are acquired by one who studies the exact sciences. In addition, the mastery of a science results in the confidence engendered by an intellectual triumph that makes subsequent tasks easier. Science teaches its student the principles of logical method. He knows a premise or an axiom when he sees one, and he knows how to use rigorous syllogistic reasoning to obtain conclusions in which he has confidence. He realizes that in so doing he has elicited no new fact, but merely altered his point of view, though this is frequently most fruitful in leading to the revelation of new and suggestive relationships. Science brings out most clearly that careful observation is the raw material of accurate thought. If the original data are in error no amount of correct reasoning will provide him with significant results, for nothing will emerge from any amount of ratiocination that is not inherent in the premises. Conversely, if his data are correct, but his reasoning is not rigorous, he will be led into error. Finally, a study of science provides him with the essential technique for checking his conclusions by resorting to additional observation and experiment. This appeal to the facts is always the court of last resort. The prediction of hitherto un-

suspected facts and their subsequent experimental verification represents the culmination of man's logical rational endowment.

If this method were really understood in its true inwardness and applied by all educated men, the world would be a simpler and less fretful habitation. As an example, I have heard one of our leading political and social scientists say that the implication in the word science applies to this subject more from hope than from achievement. In this field the data are hard to get and require a skilful and impartial sorting and interpretation that they are seldom accorded. The pressure to avoid wishful and non-rigorous thinking is resisted only by the most independent exponents of intellectual honesty. What valid conclusions can be drawn are more frequently than not distorted or wilfully misinterpreted by special pleaders. The fact that errors are committed and incorrect results reached is concealed by pride and special interest rather than exposed by unbiased analysis. The emotional element that is injected into matters concerned with our livelihood or human relationships has so far retarded the application of the rational methods of science that it is rare to encounter a political or social decision that has been based on the pertinent facts or merits.

I am not such a pessimist as to believe that we can never surmount our primordial instincts, emotions and narrow self-interest, in those matters where the common good so demonstrably requires rational ideals and behavior. But it is unlikely to be accomplished rapidly by the methods, if they can be called such, at present in use. The difficulties that are encountered in extending the nice interplay of induction and deduction, which characterizes the scientific method, beyond the inanimate spheres are most formidable and must be clearly recognized. The most difficult stage in the organization of any field of knowledge is the first one in which the qualitative laws are formulated and quantitative procedural definitions are established. Clear, precise definitions are an essential for subsequent quantitative development. Outside the sciences there is no established precedent and the first steps carry little conviction. Whitehead makes the following statement in regard to mathematics, which is true to an even greater degree for the physical sciences and is probably the reason that other branches of knowledge have not even reached the first stages of ordered description: "In mathematics the greatest degree of self-evidence is usually not to be found quite at the beginning but at some later point; hence the earlier deductions, until they reach this point, give reasons rather for believing the premises because true consequences follow from them, than for believing the consequences because they follow from the premises." The initial inductive processes which lie at the very foundation of any organized field of knowledge carry little conviction in themselves. They, and the subsequent inductive and deductive steps, acquire cogency as we gain confidence in the correctness and significance of the conclusions. The exact sciences have developed somewhat past this point and the existence of a well-tested theory lends credibility to a conclusion, though the last word is always with experiment. But in the other branches of knowledge the degree of establishment of the fundamental principles has yet to reach the stage where they are really valid evidence for trusting conclusions based upon them. As this is the slowest and least encouraging stage of development our current failure to live logically is no cause to despair of our ultimately applying the scientific method to the less exact sciences and to human social and political activities.

The bed-rock of rigorous method rises closer to the surface in mathematics and the physical sciences than anywhere else

in the curriculum, because of the simplicity of the fundamental concepts that are here involved and the formal symbolic structure that has been developed for the reasoning and the statement of conclusions. Unfortunately, there is no analogous structure available in other fields of learning, and ordinary language must be used. The limitation thus imposed constitutes one of the chief difficulties both in the formulation of definitions and in their subsequent discussion. As Whitehead says: "The appearance of contradiction is always due to the presence of words embodying a concealed type of ambiguity, and the solution of the apparent contradiction lies in bringing the concealed ambiguity to light." Words, however, must be used in any extension of the scientific method, for no formal symbolism such as that of mathematical logic exists in other fields. But they must be used with the greatest care and the utmost suspicion in view of our extreme fallibility. The implications and connotations of many ordinary words are such as to largely unfit them for the precise expression of ideas. Just as the word "liberal" may have a number of so-called "specific meanings" and an indefinite cloud of associational significance for each individual, so do all but the simplest words. The technical perfection of the transmission of speech is such that our voices can be made audible on the opposite side of the world, but unfortunately the communication of ideas from one head to another is in no such satisfactory state. With only the imperfect channel of language available it is highly dubious whether ideas can ever be transferred with sufficient precision to justify certainty of conclusion. It is merely a pious hope on my part that the mental images aroused in you by the words I write have some few fundamental characteristics in common with what I have in mind. The limitations that are thus imposed on the ordinary discourse of politics, art, literature, and so forth, must be explicitly recognized if the grossest errors are to be avoided. The pitfalls inherent in the careless use of words and loose argument are particularly evident to one who is familiar with the discipline and rigor of science. It is clear to him that the predictions of a scientific theory have a strong *a priori* probability only because of the soundness and adequacy of the underlying data and the correctness of the reasoning based upon them. A familiarity with these methods acts as a touchstone with which to gauge the relative cogency of any conclusion. If the data are dubious or incomplete or if the reasoning based upon them is ambiguous, argument is pointless. The conclusions may or may not be true, additional observations will alone decide, but they receive no *a priori* support nor do they suffer any prejudice from what is essentially an irrelevant argument.

In considering the second aspect of the rôle of science in education, the various authorities display more unanimity of opinion than might be expected in defining education as the introduction of the maturing individual into the life and culture of the group. The most succinct definition of culture is that it is the intellectual content of civilization. As our present civilization is particularly characterized by its scientific achievements, the exact sciences are the most cultural subjects in the curriculum. Malinowski goes somewhat farther in the Encyclopedia of the Social Sciences and states that: "Culture consists of a body of commodities and instrumental artifacts as well as customs and bodily or mental habits which work directly or indirectly for the satisfaction of human needs." This introduces a second cultural aspect of science as including the material products of its application. A Hospital, the Empire State Building, the Pennsylvania Railroad and the *Queen Mary* are most striking symbols of our culture, and all

the principles of their construction and operation are based directly on the exact sciences.

The flowering of the scientific method is the chief intellectual triumph of our civilization judged both by the subjective satisfaction it yields and by the objective results that it has achieved. At present it is less widely applied than its potentialities warrant, and the full force of the method has been felt but little beyond the fields of mathematics and the exact sciences. In these fields one sees clearly the successive stages of development associated with the scientific method. There is the initial accumulation of qualitative data, which suggest relationships between observable quantities. This is the most difficult stage of development, as it involves the formation of new mental concepts and connections. Then follows the quantitative formulation, including the establishment of the essential definitions, in order that the subject-matter may be clearly and unambiguously stated. This inductive process leads to the theoretical structure which takes on more definite and detailed form by further experimental accretion. A well-made, crucial experiment is the fundamental building stone in the scientific structure which is held in a unified whole by the connections of theory. Unessential protuberances and excrescences are later pruned away by the introduction of the axiomatic and deductive point of view. The essential fundamental concepts and crucial experiments are winnowed from the inevitable chaff that accompanies the first gropings for an ordered description of phenomena, which characterize the initial stages of a science. The theory is modified and extended, its interpretations are broadened and frequently its outlook is completely reversed without in any way disturbing the foundations which were built on careful and accurate data of observation. The final test of a scientific theory is its fruitfulness; the verifiable predictions that it makes. These predictions are all inherent in the original data, though they are not immediately obvious, but are suggested or brought to light by logical deduction. A theory that is not forward-looking and does not lead to significant extensions and advancements is merely a beautiful but sterile structure of the imagination.

If science is understood as an ordered quantitative description of material data, many of the misapprehensions regarding conflicts with human emotional processes are avoided. Science has nothing definite to say about what it can not define procedurally and measure quantitatively. Oddly enough it has no concern with what I believe to be the popular conception of reality, as the accurate correspondence of our observations with some transcending unobservable actuality. No scientist would contend that any theory or entity introduced to simplify description has reality in any such unscientific sense. It is no part of the physical sciences that an atom or electron is real, or that a theory is true, in any other implication than that it predicts correct observable results, and leads to hitherto unrealized relationships. On looking back over the historical development of the sciences it is evident that many of the false starts and blind alleys that have temporarily impeded progress have been due to over-active imaginations, which have carried analogies to unjustified extremes and clothed conclusions, that could not be directly tested, with an unwarranted and incongruous significance. In physics we speak of an electron or an atom as a particle, but in so doing, we realize that we must not complete the implied analogy and endow these entities with such characteristics as: shape, color, localized boundaries, hardness, and so forth, which are not their attributes at all. Analogies and the mechanistic visualization of atomic or biological processes are frequently most suggestive, but if

their implications can not be tested, they are to be regarded with suspicion.

Popular interpreters of science tell most interesting and instructive stories and fill an important place in our society. The fact that they cloak their material with a specious simplicity is hardly a valid objection to their method, for in essence science is simple once it is thoroughly understood. Too often, however, they do not sufficiently guard the reader against unjustified extensions of their arguments by stating with sufficient clarity the limitations imposed on the validity of their conclusions. More confusion than insight is apt to result from the elaborate exorcism of imaginary bogies, such as the conflict between science and the arts of religion. This is mere windmill tilting, and it would be better to point out the complete isolation of science from concern in any but intellectual and material problems. Fields having no point of contact can not by any stretch of the imagination be in conflict. The matter is not clarified by the dark sayings of certain mathematicians who have modestly referred to God as "The great mathematician," "The great geometer," and so forth. The undefinable subject of this statement can never *per se* be endowed with any scientific significance. Aphorisms of this type are the result of some mental configuration that the authors wish to express in words, and they doubtless conjure up some hazy mental picture in the minds of the auditors as well. But it is idle to endow such statements with any objective significance, and preposterous to presume that the author and auditor have even remotely the same thing in mind. I believe that God has never been called a great scientist, which is due less to our inherent modesty than to an attitude of mind that inhibits such a meaningless concept.

A discussion of the scientific contribution to our civilization through the material evidences and artifacts that have been evolved would lead us too far afield. But their effect on our mental processes and the reaction of material and technical successes on our ordered thought is a definite phenomenon of the culture of our age, and as such, deserves brief comment. The importance of this aspect is recognized by Gilbert Murray when he writes: "A machine is a great moral educator. If a horse or donkey won't go, men lose their tempers and beat it; if a machine won't go there is no use beating it. You have to think and try till you find out what is wrong. That is real education." There is much truth in the idea that we receive a very direct type of intellectual and moral education from our own mechanical devices. A machine is a self-evident proposition that is a most convincing argument for scientific principles. The simplicity of its elements when they are taken apart and lie before you, its direct functional character with nothing unessential or extraneous, its speed, precision, and rhythm, and the satisfying sense of ordered consequence it evokes are all educators. I have no doubt that they have restored to many men their confidence in the ultimate rationality of their universe, when faced by the unjust, irrational and feckless conduct of their human companions. It is not surprising that a racial predilection for metaphysics should lead Kipling's McAndrew to rationalize the universe satisfactorily to himself in terms of his ship's engines, and to see "Predestination in the stride of yon connecting rod." A skilled artisan is to some extent an educated man, not alone through the skill he possesses, but because of the mental habits formed by his association with mechanism. This is evident to me when I contrast the garage mechanic of to-day with the livery stable man of my boyhood. Here are men more or less comparable in formal instruction and with little, if any, book-learning. But there is no comparison in their intellectual acuity and in

their logical handling of material or mental processes. Of course, they are eminently practical men and do not tend to generalize from their machines to themselves and their companions, but the germ of the concept and methodology is there, and they are potentially better citizens of an ordered society.

Finally, the third and most important aspect of science for its real students is the end which it itself provides. The goal of a student varies with his training, temperament and degree of natural endowment, and it seldom becomes apparent before several years of study and training in the ideas and methods of a science. Then, however, a student gradually becomes aware of an abstract logically beautiful structure embodying what generations of scientists have succeeded in quarrying from their physical environment, and shaping through careful analysis and interpretation till the stones fit keyed together in an unshakable edifice. It is a Spanish Castle of the intellect rather than the imagination, but if its outlines are clearer and more austere, it does not lack beauty, for it is the flowering of human capabilities in this sphere. The comprehension of this structure is alone an adequate recompense for a student who has persevered through the rocky and arid approaches that repel the less pertinacious. The ability to explore its halls and study the perfection of its structure and detail is a never-ending source of wonder and intellectual gratification. I would add to Kant's "Starry sky above me and moral law within me" this structure of natural law about me. The understanding of man's scientific achievements is a very worthy end of a liberal education, and it does often constitute such an end for the more contemplative temperament or for the man who must for one reason or another terminate his scientific education at this stage.

But the chief beauty of the structure for the more active and inquisitive temperament is the fact that it is unfinished, and incomplete, and will always be so. There is no more genuinely satisfying activity than in adding to it, and in completing small portions of the edifice by building on the work of others. Few of us have the ability to lay corner-stones or to envisage unbuilt wings, though this is often done unwittingly in the prosecution of what appears to be merely a routine research; the significance of the results being frequently unrecognized at the time. The necessary work of rounding out the structure and filling in the detail, which is indispensable groundwork for the larger developments and which brings in its train immediate valuable application, is work that any one qualified by temperament and training as a scientist can do. The true scientist is characterized by the 'satiable curiosity of the Elephant's Child which is piqued by all the little unexplained facts that are constantly being encountered. This curiosity is a driving force that can no more be ignored than the pangs of hunger, and when disciplined by an adequate scientific training, it leads on to the discovery of significant connections and generalities which broaden the front of knowledge. The only danger in the formal instruction and discipline which is a necesary preparation for a scientific career is that this curiosity may be withered and stultified for lack of opportunity to gratify it as it develops.

The real student is not taught, he learns. Our formal instructional schemes are, or should be, designed to facilitate this process in every way. A spark of interest and curiosity is worth an entire bonfire of reports, themes and theses. A student should be encouraged to make some original contribution to his subject, however small, at the earliest possible date in order that he may feel that the subject is his, and that he may have some small competence in a very limited field rather than that he should be in awe of a vast structure of learning, which he can

never hope to grasp in its entirety. If he has the opportunity to acquire his scientific training through assisting in research, his curiosity is sharpened and his appetite is whetted for greater accomplishments, and he is well started on the road that will lead him to the greatest of satisfactions and from which he will never wish to turn back.

This method of approach which develops the ablest men in science requires more equipment and better facilities than those that are adequate to merely expound what others have done. However, the added impetus that can thus be given, and the quality of the results obtained are its ample justification. Furthermore, the type of instructor must be suited to the method, he must be a teacher by inspiration who is a guide and mentor pointing out those things that are most worth doing and suggesting the most fruitful methods of approach and the appropriate techniques. His personality and attitude are of the greatest importance, for he teaches by contact and example. He can frequently impart his own consuming interest and vital concern in the growth of science. Once the source of energy has been fired within the student himself he goes on under his own power to acquire with avidity the necessary details of his subject. He develops rapidly when he sees the obvious necessity of mastering his field in order to go further and contribute still more to our sum of knowledge. The contrast between the method of leading a reluctant student by the hand through all the byways of known facts and techniques, before permitting him to try his wings at original contribution, and that of stimulating him as early as possible by contact with the spirit and methods of research, is that between the slow grinding locomotion of a car driven by its starter and battery, and the same car when the ignition switch is thrown and it surges ahead on the power latent within the engine itself. With a vital interest in broadening the bounds of our understanding of natural phenomena, with a background of acquaintance with the pertinent surrounding culture, and an equipment of technical competence, his formal education is complete. Like Ulysses, he will then set out "to follow knowledge like a sinking star beyond the utmost bounds of human thought."

BOOKS ON SCIENCE FOR LAYMEN

CONSIDER THE WEATHER[1]

SIR NAPIER has enlarged his delightful drama by nearly 40 pages, and our only regret is that he did not enlarge it more, for all he says is both interesting and informative. The idea of superpersonifying the weather into a drama for which the whole world is the stage might occur to almost any creative writer of artistic mood, but only the abundant knowledge, the facile pen and the ready wit of Sir Napier could make real, as he has made real, this daring dream.

The 48-page prologue deals with "Pageantry in the Sky"—clouds of various kinds, the rainbow, snow crystals, lightning and mirage—all well illustrated and clearly described. This pleasing introduction is followed by an informative account of what the more highly cultured of the ancient peoples—Babylonians, Hebrews, Greeks and Romans—thought about weather phenomena. Many of them, like Aristotle, explained natural phenomena as owing to natural causes. Many others, however, and eventually practically every one, regarded all weather phenomena as special acts of the particular god or gods they themselves worshipped—an increase, perhaps, of abiding faith at the expense of robust reasoning. To-day we look again for natural causes of the state and condition of the sky, just as Aristotle did twenty-three centuries ago, with our faith reserved for things unseen. None of these cultured ancients, Sir Napier tells us, had any word for "weather," just such expressions as "cold period," "wet time" and the like. Don't blame them, for the generalized concept is not very precise, nor as easy to formulate as one might suppose. Try it.

Thousands of years ago weather sequences were carefully noted, especially in relation to husbandry and shipping, and much of this information was embodied in terse and useful proverbs. Soon, however, many false signs got mixed in with the true, and then the whole lain over with the sickly hue of astrology. Still, good grain survives in the abundant chaff, if only we take the trouble to winnow it out.

The various weather elements, and how they are measured, are discussed in some detail; and the information gathered by means of the instruments clearly set out with many maps and diagrams.

Any one can read "The Drama of Weather" with pleasure and with profit, and the more he already knows about meteorology the keener will be his enjoyment of this book.

One little caution to the American reader: When Sir Napier says, impressively, that there are 10 billion tons more air over the northern hemisphere in January than in July, an American would say eleven trillion more. That, of course, is because the Englishman's ton is one tenth greater than the American's ton, and his billion a thousand fold the American's billion. Sometimes words are quite confusing; if an Englishman, for instance, should give an address on shearing hogs his fellow countrymen would know that he meant *sheep,* whereas all Americans present would feel certain that the crop would be more noise than wool!

W. J. HUMPHREYS

[1] *The Drama of Weather.* By Sir Napier Shaw. Second Edition. Illustrated. xiv + 307 pp. $3.50. Cambridge University Press (Macmillan).

FIRST VOLUME OF SIGMA XI LECTURES[1]

THE results of one of the most significant movements in the American science scene of the past few years, the intellectual Chautauqua circuit for Sigma Xi chapters that is in successful operation for its third year, are brought by this volume to many who were not able to be in the audiences of the eminent lecturers at the universities.

As Dr. Harlow Shapley, of Harvard

[1] *Science in Progress.* Edited by G. A. Baitsell. Illustrated. xiv + 322 pp. $4.00. Yale University Press.

University, remarks in the foreword, "an encyclopedist of a century or so ago could gather into fruitful comprehension the facts and theories of all branches of science." That can not be done to-day, so vast is the scope of science. And even this compilation of the Sigma Xi national lectures of 1937 and 1938 can hardly accomplish this task. But, as Dr. Shapley observes, there is a unification of another sort, a theme of technique that runs through all the contributions to knowledge in these chapter-lectures. Many of the same technical tools are used throughout the various branches of science, and there is the general use of "the most common instrument of all reasoned experimental science—the balanced alternation of guiding hypothesis and experimental test."

It is altogether fitting that the men who do significant and important research should tell others about it, not alone in the technical articles of their specialized fields, but upon the lecture platform where their fellow workers and intelligent laymen may see them and hear their own presentations. Discovery and experiment is but the beginning of scientific progress. Research must be understood, spread into other minds, and perchance applied. The lecture method may seem to be rather old-fashioned in a day of nation-wide radio hook-ups, wide publicity through press and magazine, and motion pictures. There is still the warmth and reality of the personal platform appearance that has many advantages.

To a large degree this personal contact between scientist and audience exist in this volume so far as print and pictures can reproduce it. The ten eminent scientists are talking to an intelligent audience about the work they have done, foregoing the shorthand of technical jargon that is proper and useful in the merely technical report.

Sigma Xi's national president, Professor George A. Baitsell, of Yale, has brought together with care and pleasing format the ten chapters, ninety illustrations, twenty tables and ample references to the original literature. The range is from atoms to elephants.

Professor E. O. Lawrence, of the University of California, tells of atoms, old and new, giving survey of transmutation and atomic synthesis in relation to the world of elements and living things. Nobelist Harold C. Urey, of Columbia, discusses the important separation of the isotopes and their use in chemistry and biology. The new knowledge about the viruses, those entities in the borderland between the living and the non-living, is the subject of chapters by Dr. W. M. Stanley and Dr. L. O. Kunkel, both of the Rockefeller Institute for Medical Research at Princeton. Dr. Karl E. Mason, of the Vanderbilt School of Medicine, discusses vitamins and hormones, while Dr. R. R. Williams, of Bell Telephone Laboratories, tells of the general rôle of his beloved and important thiamin vitamin in living things. Dr. Edgar Allen, of Yale, speaks authoritatively upon the internal secretions in reproduction. Taking us into the intricacies of the chromosomes, Dr. T. S. Painter, of the University of Texas, assays their application to genetics. The important problem of electrical potentials in the human brain, which seems to touch upon the essence of life itself, is the subject of the chapter by Professor E. Newton Harvey, of Princeton University. Living physiology in one of its most important phases, metabolism, is the subject of the contribution of Dr. Francis G. Benedict, of the Carnegie Nutrition Laboratory, Boston, and he has studied animals, from mouse to elephant, not omitting man.

This volume, and the subsequent ones that are promised to result from more years of Sigma Xi lectures, will be considered important contributions to understanding the progress of science. After being read, they will do important reference shelf service.

WATSON DAVIS

DON'T WORRY[1]

"This book is written for and about normal people—people who can lay the foundations of their own emotional discomforts, nurture them to inconvenient intensity and learn with ease to control them." In other words, it is for and about the worrier who, in spite of his mental discomforts, is not regarded as psychotic.

The author evidently aims to aid those of his readers who are worriers. Having had much practise in helping and curing worriers, as numerous remarks in the book indicate, he approaches the subject from the point of view of the healer as much as from that of the scientist. He begins by assuring his readers that it is the exceptionally intelligent who worry, and that it is modern civilization that causes them to worry. Consequently the worrier first is flattered and then is provided with an excuse for his condition. Probably only a small fraction of worriers will question these doubtful, if flattering and consoling, generalizations.

At once the author proceeds to explain the process of becoming a worrier and the method of escaping from being a worrier. Passing lightly over possible physical and experiential causes, he maintains that worrying is the result of learning to worry by practice, and that, consequently, the remedy is to unlearn to worry by ceasing to practice worrying. This bald statement does not do justice to the sound counsel given by the author to those who worry. Yet the essence of his thesis is: "Worry is psychological. Psychological conditions are learned. Learning requires practice. Forgetting operates on everything learned. Practice prevents forgetting."

The discussions of common characteristics of worriers and of the interrelations of the emotions and the physiological processes will find a response in the minds of most readers who belong to this afflicted class. Case histories of those whom the author has helped or cured illustrate the points made and inspire a hopeful outlook. The discussions of methods for correcting bad mental habits and of some "practice procedures" will be helpful, even if they are not profound; the discussion of fears is more fundamental but will not be so readily appreciated by the scientifically immature. The style of writing, consisting very largely of slightly telescoped simple declarative sentences, as illustrated in the quotation above, is somewhat tiring, but the book is sane and deserves a wide circulation among the unhappy victims of worry.

F. R. M.

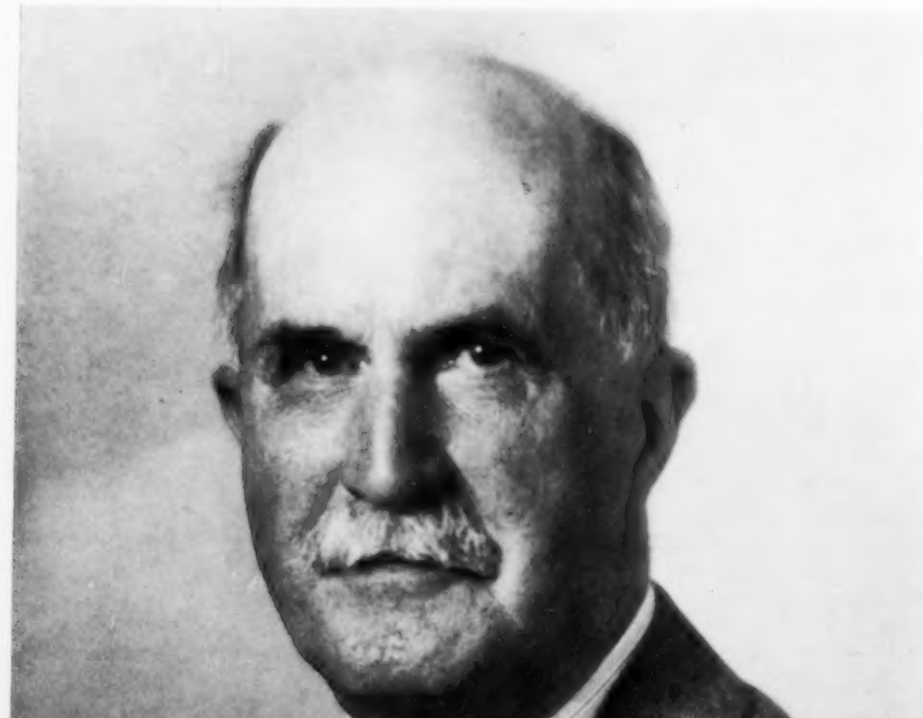
[1] *In the Name of Common Sense.* By Matthew N. Chappell. 192 pp. $1.75. Macmillan Company.

ABOUT BIRDS[1]

This is a book preeminently notable for its very fine photographic illustrations and for the fact that it does not follow the well-worn path of identification manuals. After an introductory chapter entitled "Why Know Birds?" it takes up the following broad topics, the illustrative cases of which are largely culled from the author's own experience in Nebraska, Illinois, New York and California—the homes and home life of birds up to the time the young are able to care for themselves, the food and feeding methods of birds, the kinds of feathers and their replacement, the migrations of birds, protective coloration and defense actions of birds, the general features of bird classification, the social parasitism of the cowbird and a concluding chapter on how to know the names of birds, how to attract them and how to study their habits. The simplicity of the treatment throughout is evidently a plan on the author's part to make the book appealing and useful to a wide audience of beginners in bird study. In this plan he has been successful.

H. Friedmann

[1] *Birds.* By Gayle Pickwell. Illustrated. xvi + 252 pp. $3.50. Whittlesey House, McGraw-Hill Book Company.



—*Underwood & Underwood*

SIR WILLIAM BRAGG

RECIPIENT OF THE JOHN J. CARTY MEDAL, WHO DELIVERED THE PILGRIM TRUST LECTURE BEFORE THE NATIONAL ACADEMY OF SCIENCES ON "HISTORY IN THE ARCHIVES OF THE ROYAL SOCIETY."

THE PROGRESS OF SCIENCE

MEDALLISTS OF THE NATIONAL ACADEMY OF SCIENCES

At the seventy-sixth meeting of the National Academy of Sciences, held this year on April 24, 25 and 26 in Washington, four medals were presented to scientists for noteworthy contributions to science. Each medal was awarded on recommendation by the committee appointed to administer the special fund responsible for the medal. At present there are eleven trust funds, controlled by the academy, the income from which defrays the expenses connected with the awards of medals in specified fields of science; several of these funds provide honoraria in addition to the medals. The names of the medals from these trust funds and the branches of science designated therein are: Agassiz Medal, oceanography (17 awards have been made from this fund); Barnard Medal, physics and astronomy (7 awards); Carty Medal and honorarium, any field of science coming within the scope of the charter of the academy (3 awards); Comstock Prize award, electricity, magnetism and radiant energy (6 awards); J. Lawrence Smith Medal, meteoric bodies (2 awards); Thompson Medal and honorarium, geology and paleontology (10 awards); Walcott Medal and honorarium, paleontology of Pre-Cambrian and of Cambrian (1 award); Watson Medal, astronomy (10 awards); Hartley Welfare Medal, application of science to public welfare (16 awards). This list shows clearly that the academy is restricted, by virtue of the terms of gift in each trust fund, to definite fields of science in which it may honor investigators for meritorious work. These fields and the number of medals awarded in each field are: astronomy and astrophysics, 35; physics, 13; meteorites, 2; geology, 4; paleontology, 14; zoology, 13; oceanography, 17; engineering, 1; application of science to the public welfare, 16. The first medal was awarded in 1886; since then the academy has made 113 medal awards. During the years 1886 to 1912, inclusive (27 years), sixteen medals were presented, approximately one medal every other year; from 1913 to April, 1939 (27 years), 97 medals were awarded, approximately four per year.

The membership of the academy is divided into eleven sections, representing different fields of research in science. The distribution, among these sections, of academy medallists who are now academy members is as follows: mathematics, 0; astronomy, 10; physics, 4; engineering, 1; chemistry, 1; geology and paleontology, 4; botany, 0; zoology, 4; physiology and biochemistry, 0; pathology and bacteriology, 0; anthropology and psychology, 0. In the sections of engineering and of chemistry, the awards were made for applications of science to the public welfare rather than for special contributions to these fields of research. The data show that in seven of the eleven sections little, if any, provision has been made in the existing trust funds for the award of medals to workers in the fields represented by these sections. This situation indicates a lack of equality of treatment with respect to a large number of academy members and others in certain branches of research work in science. The academy is powerless to change the situation; the remedy lies in the establishment of additional trust funds that shall include the fields, now neglected, either specifically or in such form that it will be possible for the academy to honor a worker in any field of science by the award of a medal for noteworthy accomplishment. Experience has shown that a trust fund which imposes severe limitations on the awards made from it may not accomplish its purpose so well as one in

DR. HARALD U. SVERDRUP

which the conditions of award are less strictly prescribed and a greater degree of freedom is allowed the trust fund committee in selection of a candidate for the honor.

Each medal is presented by the president of the academy to the recipient at the time of the annual dinner. Preceding the formal presentation of the medals, the president reports upon the status of the academy and reviews briefly its activities and accomplishments during the year. Following his address, he calls upon the chairman or member of the trust fund committee that recommended the award of the medal to state the reasons that led the committee to select the candidate for the honor. The president then, on behalf of the academy, presents the medal to the recipient, who, in turn, replies briefly in words of appreciation for the honor and refers to the research work that influenced the committee in its decision.

The Agassiz Medal for Oceanography was awarded to Harald Ulrik Sverdrup, director of the Scripps Institution of Oceanography, of the University of California, at La Jolla, California, and professor of geophysics in the Christian Michelson Institute of Bergen, Norway, for his personal oceanographic explorations in Arctic regions and his numerous contributions to physical oceanography and the interrelations between the sea and the atmosphere. The presentation address was made by Dr. T. Wayland Vaughan, chairman of the Agassiz Fund Committee at the time the award was recommended to the academy. Dr. Vaughan referred to the oceanographic work of Dr. Sverdrup in the Arctic regions, emphasizing especially the results obtained by Dr. Sverdrup from 1918 to 1920 and 1922 to 1925 aboard the vessel *Maud* under Amundsen's general direction, and also his important contributions, theoretical and practical, to dynamical oceanography and meteorology, and to the mechanics of the movements of ocean waters. In reply Dr. Sverdrup expressed gratitude for the medal from the National Academy of Sciences; he appreciated the honor especially because from his early days he has been associated with American institutions, in particular the Carnegie Institution of Washington, and has many friends in this country. Through his connection with the Scripps Institution of Oceanography he now has the opportunity, long desired, to do oceanographic work in part of the Pacific Ocean, which is a vast field for investigation. He suggested that it would be fitting to honor the memory of Alexander Agassiz by organization of a large-scale Alexander Agassiz Expedition for exploration of the Pacific Ocean. The value of such an expedition would be very great.

The John J. Carty Medal and Honorarium for the Advancement of Science, consisting of a gold medal, bronze replica, certificate and $3,000 in cash was awarded to Sir William Bragg, director of the Royal Institution and of the Davy-Faraday Research Laboratory and pres-

ident of the Royal Society of London, England, for his fundamental work in x-ray crystal analysis and the development of a new method and approach to this field of the atomic structure of crystals. His studies have given birth to a new tool that is bringing to light important facts regarding such complex structures as the larger organic molecules. Dr. Frank B. Jewett, chairman of the John J. Carty Fund committee, in his presentation address reviewed briefly the work of Sir William as an investigator, an able and inspiring teacher and a leader in guiding and advising with respect to matters of applied science. Following Dr. Jewett, Dr. Arthur H. Compton spoke in greater detail of the work of Sir William and of his many contributions to science and to the diffusion of knowledge of the achievements of science and of its methods. In reply, Sir William voiced sincere appreciation of the honor, but stressed the important part played by his son and others in the work specified in the award of the John J. Carty Medal.

The Daniel Giraud Elliot Medal for 1933 and accompanying Honorarium of $200 was awarded to Richard Swann Lull, of the Peabody Museum of Natural History, Yale University, New Haven, Connecticut, in recognition of his work entitled "A Revision of the Ceratopsia or Horned Dinosaurs," published in the Memoirs of the Peabody Museum of Natural History. Dr. W. B. Scott, on behalf of the committee on the Daniel Giraud Elliot Fund, made the presentation address and referred to Dr. Lull's Monograph on the Horned Dinosaurs as a very comprehensive and thorough piece of work. In this monograph the material scattered through various museums in the United States and Canada is described in detail, together with an account of the habitats and manner of life of these great reptiles. The treatise closes with a discussion of the evolution of this Upper Cretaceous group in which the great quantity of material is marshalled in an orderly way and their mutual relations are admirably discussed. In response Dr. Lull expressed appreciation of the medal award by quoting from a note recently received from Japan: "It is with 'the greatest honor and unutterable throb of heart I feel in offering you this word of thanks.'" Dr. Lull referred to the proposal made many years ago by Othniel C. Marsh, of Yale University, to prepare a series of monographs on the very large collections of fossil vertebrates gathered under his direction. Of these memoirs Dr. Marsh prepared two, Dr. H. F. Osborn, several others, and Dr. Lull, the one on Ceratopsia, published in 1906. The 1934 monograph on the same group assembles the knowledge gained by many investigators from discoveries made since 1906.

The Daniel Giraud Elliot Medal for 1934 and accompanying Honorarium of $200 was awarded to Theophilus Shickel Painter, of the University of Texas,

PROFESSOR RICHARD S. LULL

PROFESSOR THEOPHILUS S. PAINTER

Austin, Texas, in recognition of his work on the chromosomes of the salivary glands in Drosophila in relation to the problems of mutations and genetics, published in *Genetics* and the *Journal of Heredity* in 1934. In his presentation speech Dr. Ross G. Harrison, chairman of the committee on the Daniel Giraud Elliot Fund, reviewed the work by Dr. Painter on the chromosomes in the salivary gland cells of Drosophila in which the constancy of the band pattern in corresponding chromosomes and the difference between the several chromosomes with regard to this pattern was discovered. Dr. Painter showed that these bands mark the positions of the genes in the same order as had been postulated from the cross-over studies by T. H. Morgan and his school. This discovery has greatly facilitated the study of the relation between chromosome pattern and hereditary processes and has added much to our knowledge of the positions of the submicroscopic gene elements in chromosomes. In reply Dr. Painter voiced his appreciation of the honor bestowed on him in the award of this medal and attributed his success in correlating the position of gene loci with definite bands along salivary gland chromosomes to three fortunate circumstances. Under Dr. Muller he had plotted the position of gene loci in metaphase chromosomes and realized then that the large persistent spireme threads of salivary glands might furnish promising results. By use of the stain, aceto-carmine, on crushed mounts he was able to study the salivary chromosomes satisfactorily. Fortunately, in the research institution in which he was then working enough of these broken chromosomes, that had been analyzed genetically, were available for study and on them the observations were made that allowed inferences to be drawn regarding the positions of the genes relative to the bands of the chromosomes.

F. E. WRIGHT,
Home Secretary

REFLECTIONS ON THE MILWAUKEE MEETING

THE programs of the Milwaukee meeting (June 19 to 24) of the American Association for the Advancement of Science illustrate the great variety of interests of scientists and the corresponding wide differences in their reactions to an environment.

To geologists the area that includes Milwaukee is one that has had a varied and interesting history for 2,000 million years. In the early part of this period there were convulsions and intrusions and extrusions of liquid magmas from which geologic agencies eventually produced rich deposits of iron ore and copper. (The geologists have excursions to these regions.) In later periods sediments and deposits of lime accumulated

while the waters of shallow seas repeatedly rolled over this region. Only yesterday, as it were, great sheets of ice pushed irresistibly down from the north and produced fertile soil and numerous deposits of gravel. To geographers the area is one of precious natural resources to be preserved. They have organized a symposium on soil conservation and land utilization in the region.

To biologists Wisconsin and neighboring states have a varied natural flora and fauna and offer unsurpassed opportunities for the production of plants and animals useful to civilized man. A symposium and many other papers are devoted to discussions in this field.

To anthropologists the area in which Milwaukee is located has been the home of men for several thousand years, possibly since shortly after the last retreat of glacial ice. The numerous mounds of these peoples reveal a fascinating story of their approaches toward civilization which is only now being read.

To the members of the Section on the Social and Economic Sciences Milwaukee is a great center of industry and social organization which is notable for the high standards that have been maintained in its government. Unremembered are the great events of its geological history, important as they may have been in producing the present natural wealth of the region. Forgotten are the prehistoric men who once roamed its prairies and forests, as are the Indians who were disputing its possession with white men only a century ago. Thus to every group of scientists a geographical area is entirely different.

Milwaukee, from an Indian word meaning "good lands," was first visited by white men in 1673 when Father Marquette and Louis Joliet, returning from a voyage down the Mississippi River, skirted the left shores of Lake Michigan. It is believed that La Salle stopped at the site of Milwaukee in 1679, which he referred to as "Millioke." No Europeans, except possibly French voyageurs and fur traders, traversed the western shores of Lake Michigan for nearly a century until the Englishman Alexander Henry

—Milwaukee Public Museum Photo

MILWAUKEE PUBLIC MUSEUM AND LIBRARY BUILDING

—*Milwaukee Public Museum Photo*

THE MILWAUKEE COUNTY GENERAL HOSPITAL

visited the site of Milwaukee in 1760. In 1795 Jacques Vieau established a permanent post at Milwaukee for the North-Western Fur Company, which was maintained until it was succeeded by Astor's American Fur Company in 1820.

Colonists began to arrive in the neighborhood of Milwaukee in 1833, the year in which Morgan L. Martin surveyed the harbor. The first saw-mill was constructed in 1834, following which three villages sprang up, Juneautown, Kilbourntown and Walker's Point. In 1846 they were united and incorporated as the City of Milwaukee. Milwaukee became a center of the lumber industry and for several decades was the metropolis of the Great Lakes. The first mayor of the city was Solomon Juneau. For 40 years the Fire and Marine Insurance Bank, which was opened in 1839, was one of the strongest and most favorably known banks west of the Allegheny Mountains.

Milwaukee has been an intelligent and progressive community from its earliest days. On July 14, 1836, its first newspaper, *The Milwaukee Advertiser*, began publication. Its first public school was opened in 1839. Its first telegraph line, connecting the city with Chicago, was put into operation in 1849, and its first railway in 1856. Milwaukee owes much to the immigrants who began to arrive from Germany in large numbers in 1840. In 1900 about 72 per cent. of the population of Milwaukee was of either German birth or the children of German-born parents. Reflection on the amazing changes that have taken place in Milwaukee and surrounding territory within a century makes one wonder whether there will be similar changes during the next century. As great as they have been, they have not exceeded those that have taken place in science. This has been a rapidly changing world.

F. R. Moulton

THE WHITNEY WING OF THE AMERICAN MUSEUM OF NATURAL HISTORY

On June 6, 1939, the American Museum of Natural History, New York, dedicated a new wing of its structure devoted wholly to the Department of Birds. In the presence of members of the Whitney family and 400 guests, addresses signalizing the event were made by President F. Trubee Davison; Mr. Cornelius Vanderbilt Whitney, in the double capacity of trustee of the museum and representative of the three generations of his family which have befriended the institution; Dr. Leonard C. Sanford, a trustee whose particular interest is ornithology; Dr. Frank M. Chapman, for more than fifty years head of the Department of Birds, and Dr. Robert Cushman Murphy, curator of oceanic birds.

The building was given jointly by the late Mr. Harry Payne Whitney and the City of New York. It is a memorial to Mr. William C. Whitney, Secretary of the Navy during the first administration of President Cleveland and patron of American Museum researches relating to fossil horses and other Tertiary mammals. After the death of the donor, in 1930, Mrs. Harry Payne Whitney and their three children, Mr. C. V. Whitney, Mrs. G. Macculloch Miller and Mrs. Barklie McKee Henry, continued to support development of the equipment, collections and exhibits of the department, their greatest single gift being the 280,000 study skins of birds amassed by the late Lord Rothschild and formerly housed in his Zoological Museum at Tring, Hertfordshire.

The Whitney Wing is a building of eight stories, three of which are devoted in whole or in part to public exhibition. Six office and laboratory floors are fitted with steel cases for the safe storage of the world's most comprehensive collec-

SEVEN OF THE HABITAT GROUPS IN WHITNEY MEMORIAL HALL

AND THE DOME OF THE SKY WHICH APPEARS TO RISE FROM THE COMMON HORIZON OF THE SEPARATE EXHIBITS.

A SCENE ON THE FAR-FAMED CHINCHA ISLANDS IN THE BAY OF PISCO, PERU

CONSPICUOUS ON THESE GUANO ISLANDS ARE THE THREE MOST IMPORTANT GUANO BIRDS, NAMELY THE PERUVIAN CORMORANT ("THE MOST VALUABLE BIRD IN THE WORLD"), THE BOOBY (ON THE CLIFFS), AND THE VERY LARGE BROWN PELICAN OF THE HUMBOLDT CURRENT.

A SCENE ON JAMES ISLAND, LOOKING TOWARD ALBEMARLE

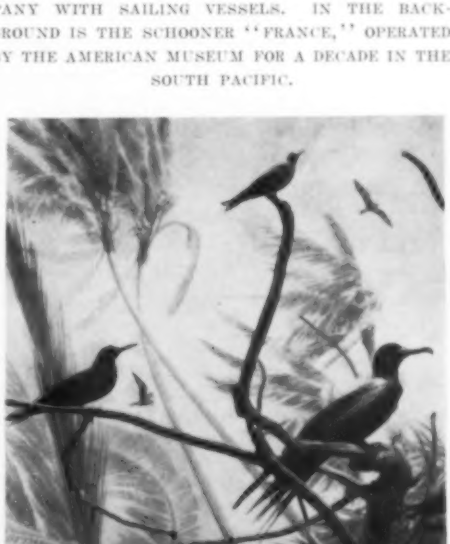
THE MOST IMPORTANT BIRDS IN THIS EXHIBIT OF GALÁPAGOS BIRD LIFE, FROM A BIOLOGICAL POINT OF VIEW, ARE 9 SPECIES OF THE FAMOUS "GALÁPAGOS FINCHES," WHICH ARE CREDITED WITH HAVING MUCH TO DO WITH DARWIN'S ORIGINAL IDEAS ON THE PRINCIPLE OF NATURAL SELECTION AS AN EXPLANATION OF EVOLUTIONARY CHANGE.

tion of birds, which now numbers approximately 750,000 specimens. The greater part of the top floor is given over to modern aviary space in which the behavior and heredity of living birds may be studied. Moisture and humidity control, sun-lamp illumination and other modern experimental auxiliaries are here provided. The broad central corridor of the fourth floor takes the form of a well-lighted art gallery, available for both permanent and temporary showings of field studies and finished paintings, prints and sculpture relating to birds. Its present installation comprises the museum's historical series of sketches by Louis Agassiz Fuertes, illustrations by Joseph Wolf executed for the lavish ornithological monographs of Dr. Daniel Giraud Elliot, several paintings by Audubon and a group of oils and watercolors by Courtenay Brandreth. The first floor is a hall of 16 alcoves, to be developed as a diagrammatic exhibit of the biology of birds and other animals. A provisional layout in four of these alcoves was ready for the opening on June 6.

SHIP-FOLLOWERS

A FEBRUARY (MID-SUMMER) DAY ON THE OCEAN SOUTHEAST OF NEW ZEALAND, WITH PETRELS AND ALBATROSSES OF VARIOUS SPECIES KEEPING COMPANY WITH SAILING VESSELS. IN THE BACKGROUND IS THE SCHOONER "FRANCE," OPERATED BY THE AMERICAN MUSEUM FOR A DECADE IN THE SOUTH PACIFIC.

Whitney Memorial Hall, on the second and main exhibition floor of the wing, comprises a diorama of the Pacific Ocean and its far-flung islands. Eighteen cases for habitat groups surround an oval floor space, on the midline of which are bronze busts of William C. Whitney (1841–1904) and Harry Payne Whitney (1872–1930), by Augustus St. Gaudens and Jo Davidson, respectively. The walls of two terminal alcoves carry mural maps which function both as decoration and a means of orientation for visitors, together with dedicatory inscriptions. The ceiling is a sky-dome, illuminated from hidden sources, which appears to rise from the common horizon on the backgrounds of the habitat groups. The painting throughout is the work of Francis Lee Jaques, of the museum staff.



BIRDS OF THE SOUTH SEA ATOLL

DETAIL OF THE HAO ISLAND GROUP, IN THE TUAMOTU ARCHIPELAGO, WITH MAN-O'-WAR BIRDS AND VARIOUS SPECIES OF TERNS FACING THE SOUTHEAST TRADE WIND.

Whitney Memorial Hall is one of the results of the Whitney South Sea Expedition of the American Museum, which since 1920 has carried on continuous or-

nithological researches among the Pacific islands with funds provided by Mr. Harry Payne Whitney.

The purpose of this hall is to show the bird life of the Pacific Ocean and its islands. The scope of the exhibits extends from sub-Antarctic latitudes in the New Zealand region northward to islands near Hawaii, at the southern border of the north temperate zone and from the coast of Peru westward to Australia, New Guinea and the Philippines. A wide range of physiography, climate, vegetation and bird life is thus illustrated, and, in conjunction with the mural maps, an effort has been made to show the effect of climatic zones, prevailing winds, ocean currents and the relative distances of island groups from the continental masses of the Old World and America, to which they owe their fauna.

Exhibits thus far installed are entitled "Ship-followers," "Samoa," "Tuamotu," "Marquesas," "Peruvian Guano Islands," "Galápagos," "Hawaii" and "Laysan." Future habitat groups will similarly represent the bird life of the Solomon Islands, Fiji, Australian Barrier Reef, New Guinea, an Antarctic outlier of New Zealand and other Pacific localities. In addition to the patronage given this hall by Mrs. Whitney, her son and two daughters, generous supplementary support of field work and group construction has come from several friends of the late Mr. Whitney or the museum, including Messrs. Templeton Crocker, Andrew G. C. Sage, Henry W. Sage and Dr. Sanford. Two of Mr. Crocker's cruises in his schooner yacht *Zaca* are, indeed, responsible for the selection of sites and the making of field studies for seven of the eight groups now completed.

AIRPLANE CRASH AT THE LICK OBSERVATORY

On Sunday evening, May 21, 1939, at about 7:11 P.M., an Army airplane collided with the main building of the Lick Observatory. The plane was of the "attack" type and is said to have been capable of a speed of 210 miles an hour; it was piloted by Lieutenant Richard F. Lorenz and carried Private W. E. Scott as a passenger. Both occupants were instantly killed. Mount Hamilton, on which the observatory stands, was enveloped in clouds at the time. The plane belonged at March Field near Riverside and was returning there from Hamilton Field near San Francisco, when it struck us. Mount Hamilton is in a direct line between the two stations, and this line bears southeast, so that the plane was on its course at the time.

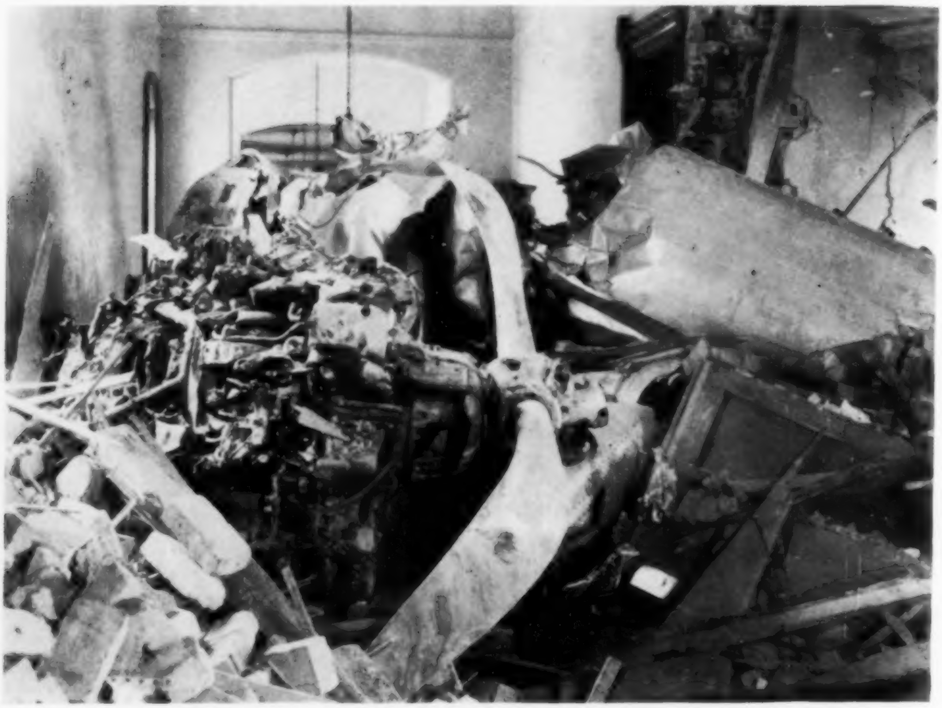
The plane struck the west façade of the building, about fifty feet north of the principal entrance, and crashed through two offices into the main observatory corridor, where it was stopped by the reinforced concrete wall which forms the east side of the building. The direction of motion within the building was, as nearly as could be determined, southeast. In its course the plane penetrated two brick walls, one 20 inches and the other 13 inches in thickness, and went diagonally through a dividing wall separating the two offices.

The engine and greater part of the fuselage were deposited in the offices and corridor, with bricks and mortar from the demolished walls.

Fig. 1 shows the area of entry. The protruding fragment is the right wing. Fig. 2 is a view of the main observatory corridor looking toward the north, and Fig. 3 is one from the other side of the wreckage, looking south. The pile of débris—plane, bricks and mortar—was 40 feet long and about 9 feet high at the crest. It required two or three days to clear this material away and to wall off the damaged section of the building for

PLACE WHERE PLANE PIERCED WEST FAÇADE OF THE OBSERVATORY

WRECKAGE IN MAIN CORRIDOR, LOOKING NORTH



MOTOR AND ACCOMPANYING WRECKAGE IN MAIN CORRIDOR, LOOKING SOUTH

the purpose of excluding dust. After that it was possible again to take up the normal activities of the observatory.

When we turn from the contemplation of the tragic consequences of the accident it is possible to derive some satisfaction from the circumstance that little or no damage was done to the scientific equipment or to photographic and other records of the observatory. The material loss is, of course, considerable, but it is believed that this will not prevent speedy rehabilitation of all the observatory's facilities.

Records of the effect of the impact of the plane are given by our seismographs and self-recording barometers. Of each of these instruments we have two types, but at the moment only one seismogram and one barogram are available for study.

The seismogram, which is from the Wiechert machine, has been examined by Dr. Jeffers and myself. The record of the disturbance appears, to the eye, as a small spot on both the west-east and north-south tracings. Examined with a glass the spots are readily seen to be minute "shock" records of about two or two and a half seconds' duration. The initial movement is in each case about 1 mm, followed by a rapid swing to a point .4 mm on the opposite side of the zero point; subsequent oscillations are not readily distinguishable, but the trace is broad during the remainder of the short interval of time above indicated. After allowing for the magnifying factor of the instrument, and otherwise reducing the data to simple terms, we find the following facts. There was a sudden displacement of the earth, at the site of the seismograph, toward the southeast, about 1/57 mm in amount. This was followed by a reverse movement totaling approximately 1/41 mm, or .001 inch, after which the vibration gradually died out. The

initial displacement corresponds, as would be expected, with the direction of flight of the airplane, that is to say from northwest to southeast. The seismograph is distant about 120 feet (36 meters) east-north-east from where the plane struck, so it is clear that a very considerable part of the mountain top was set in motion by the impact. The time of the initial displacement was 10 minutes and 59 seconds past 7 P.M., Pacific Standard Time. This figure is regarded as possibly subject to an error of a second or two; it furnishes the most reliable time of the collision now available.

The barogram to which reference has been made is that provided by the Draper mercury-weight self-recording barometer. There was a sharp barometric rise of about .013 inch and an immediate recovery. In view of the weight of the moving parts of this barometer and the short duration of the disturbance, it is probable that the actual rise in pressure was considerably in excess of the above amount. It should be stated that the barometer is situated in the observatory corridor and that some increase in pressure would be expected as a consequence of the sudden entry of the plane into the building and of the falling inward of the walls.

At the time of the accident there was one person in the building and some half dozen in the immediate vicinity. Every one remarked the roar of the approaching plane, which was obscured by the cloud in which the mountain was enveloped. The noise of the impact seems to have been effectively smothered within the building, and the single occupant mentioned did not at first realize that the building had been struck. The sudden silence following the roar of the engine indicated to all that the plane had "crashed," but, until the opening in the wall was discovered and the mutilated machine found in the observatory corridor, it was believed that the accident had occurred somewhere on the mountain side.

It may be worth relating that two visitors were just arriving at the observatory when the plane flashed across their path and buried itself in the building. Until matters were explained to them they apparently had no very clear idea of the meaning of it all. Possibly they regarded it as a mere matter of observatory routine.

As will be realized, the situation precipitated by the collision was a very serious one. Within a few seconds of time a great mass of gasoline-soaked wreckage established itself within a far-from-fireproof building. The cool and efficient manner in which the young men and women who were first on the scene adopted precautions against explosion and fire are deserving of the highest commendation. Their prompt and efficient action undoubtedly saved the observatory from a major catastrophe.

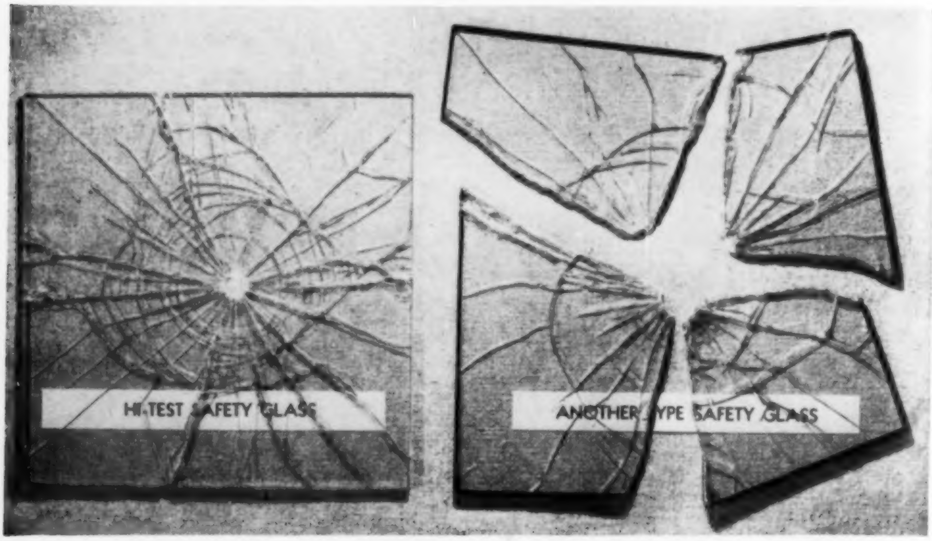
W. H. Wright

A REMARKABLE NEW SAFETY GLASS

On the last day of March, in the lecture hall of the Franklin Institute, Philadelphia, a new, modern, high-test safety glass was given its first public exhibition, the audience consisting of high officials of the chemical and automotive industries. They viewed a number of convincing demonstrations of the valuable properties of the new safety glass.

In the early days of the automobile its speed was so low that there was little use for glass as windshields; but, as speeds increased and cars were used in all weather they came to resemble a sort of traveling show-case, with glass on all sides. This glass was a constant menace, for in case of accident the flying fragments were responsible for a large majority of the injuries sustained.

It was an accident which was respon-



COMPARATIVE EFFECTS OF A STANDARD BLOW AT WINTER TEMPERATURE

sible for the germ of the idea which has grown into safety glass. In 1903, Edouard Benedictus, a French chemist, reached for a bottle on a shelf in his laboratory. He knocked another bottle to the floor. When he started to sweep up the pieces, he was startled to find that the bottle, although shattered, retained its shape. It had held collodion. The ether and alcohol had evaporated and the celluloid coating held the fragments together. Benedictus did not immediately realize the application that might be made of his discovery, nor did he perform any experiments with coated glass until he witnessed a motor accident in which a young woman was badly cut.

From the earliest safety glass to that of 1939, the fundamental principle has been the manufacture of a "sandwich," with a plastic filling between two sheets of glass. This glass provided protection from flying stones or other objects outside the car, and the danger of injury from murderous particles of glass was greatly reduced.

The first safety glass filler was a cellulose nitrate plastic, but this, it soon was learned, often became discolored from the actinic rays of the sun which penetrated the glass. This difficulty was solved by adding iron to the glass so that the harmful rays would be absorbed.

The second step in the development of safety glass was the substitution of cellulose acetate for cellulose nitrate. This material did not discolor in sunlight, because the acetate film is transparent to the actinic rays of the sun. However, this material required careful edge sealing to prevent moisture from getting in and to avoid evaporation of the plasticizer. Otherwise there would be cracks and separation at the edges.

One major disadvantage which the acetate safety glass shared with the nitrate glass was their tendency to lose toughness and strength at temperatures which are often met with in winter driving. When the temperatures of these plastics were below 20° F. they became brittle and lost almost all their safety-glass properties. Since the low temperatures of winter are often accompanied by increased driving hazards, research during the past five years has been directed toward the discovery of a new plastic film not having this defect.

As the result of this research the discovery of polyvinyl acetal resin brought the industry much closer to an ideal safety glass. It is this material that is used as a bond in the new high-test safety glass which was introduced at the Franklin Institute. Not only is the new glass much stronger than the old at ordinary temperatures, but, even when cooled to as low as 10° below zero F., it retains its safety features, indicating that protection is assured even under severe winter driving conditions.

Moreover, this new substance does not become discolored nor does it require special sealing on the edges when it is cut into special shapes from standard pieces. Since the glass part of the sandwich is plate, the result is a product of fine optical clearness, without waviness or imperfections.

Polyvinyl acetal resin is a rubbery thermoplastic material. A sheet a few thousandths of an inch thick is placed between two pieces of glass. When heated it softens to form a plastic bond, with perfect adhesion between all surfaces. While milky before being inserted into the "sandwich," the plastic sheet becomes entirely transparent during the processing.

The plastic film itself has remarkable properties. In the form of a swing it will support the weight of a man. The shock of a 15-pound bowling ball hurled upon an outstretched diaphragm is absorbed by the film. These shock absorption qualities of the resin filler are also retained by the safety glass made from it. Even though this glass is many times more resistant to shocks, sudden impact is not likely to result in fractured skulls, concussions or lacerations.

A sheet of the new high-test safety glass may be pounded until the glass is completely broken and it may then be rolled up like a rug without scattering the fragments of broken glass.

NICOL H. SMITH

DEMONSTRATION OF ELASTICITY

AFTER THIS BLOW FROM A BOWLING BALL THE MEMBRANE, 0.015 INCHES THICK, RETURNS TO ITS ORIGINAL SHAPE.

DEMONSTRATION OF STRENGTH

198 POUNDS SUPPORTED BY A STRIP OF MEMBRANE EIGHT INCHES WIDE.

THIS COMPLEX WORLD—NICKEL

Nickel is not one of the principal elements of which the earth is composed. In the rocks which make up its outer layers, there is 2,300 times as much oxygen, 1,400 times as much silicon, 400 times as much aluminum, and even 250 times as much iron. Nor is nickel an element that is a principal food of plants or animals, either uncombined with other elements or in compounds. If it is necessary at all for living organisms, it is required in only very minute quantities. It is not even used for jewelry and ornaments. Yet threads of nickel run all through the varied fabrics of civilization, and on its slender strands hang weighty problems of industry, economics and international relations.

About fifty years ago it was found that the addition of even a few per cent. of nickel to steel makes an alloy of very remarkable properties. The most important of the properties of nickel-steel alloys is that they are very much stronger and tougher than ordinary steel. Another is that the alloys, especially those containing more than 5 per cent. of nickel, are stainless and acid-resisting. Naturally the proportions of the metals that should be used to obtain alloys of specified properties and the methods of producing them were learned only after a large amount of experimentation. Moreover, until well within the present century nickel was not available in large quantities, and that which was available was costly. It was only after the development of the great nickel mines near Sudbury, Ontario, and after improving the methods of refining it, that this metal became so abundant and cheap that it could be used extensively for industrial purposes.

Recently the railways have been under severe pressure, about half of those in the country being virtually bankrupt. In order to reduce operating costs the capacities of freight cars have been steadily increased, longer trains have been hauled and greater average speeds have been attained. Now lighter equipment of a given capacity is being introduced by the use of nickel-steel alloys. An immediate result is that the weight of the cars for a given load is reduced by about 17 per cent., and a whole chain of consequences follows—engineering, maintenance, employment, economic, financial. For a given amount of traffic, right of way and equipment will require less maintenance, less steel will be used, less coal will be burned, longer trains will be hauled, and for all these reasons employment will be reduced.

The value of machine tools and machinery requiring strength and durability produced annually in this country is of the order of two billion dollars. The uses of nickel-steel alloys in these fields, especially in high-speed machine tools, are of the highest importance. The consequences in reducing costs of an endless variety of manufactured products, and therefore increasing their consumption, and in requiring less man power, modify every aspect of our social and economic and, indirectly, political order. The same thing is true of the consumption of nickel in the production of stainless and acid-resisting steels for uses in the chemical industries.

Nowadays nearly every discussion eventually leads to the question of war, as this one does. Without nickel guns could not be produced that would have ranges of many miles, naval vessels (and other ships) would be heavier and their armor more easily pierced, airplanes would have less carrying power—war of offense and defense would be entirely different. In a very long war control of the sources of nickel might be a deciding factor. Over 90 per cent. of nickel is produced in Sudbury, Canada, and a large part of the remainder in the island of New Caledonia, which is under French control.

F. R. M.